Reasoning skills, problem solving ability and academic ability: implications for study programme and career choice in the context of higher education in Thailand.

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DECLARATION

This thesis is the sole work of the author, and has not been submitted previously by any other candidate for a degree at Durham University or at any other University.

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Acknowledgements

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Abstract

Reasoning skills, problem solving ability, and academic ability: implications for programme and career choice in the context of higher education in Thailand.

This thesis examines reasoning skills, problem solving ability, and academic ability from a cohort of final year university students. The purpose of the study was to investigate the influences of academic ability on reasoning skills, and problem solving ability, and vice versa, and to examine whether students from different programmes displayed significant different levels of reasoning skills and problem solving skills. In order to choose which academic programmes to use for the study Holland's theory of 'career personality' was used.

This research used primarily quantitative data with an additional qualitative to provide an element of a mixed methods design. The data has been collected from 333 final year students in one university in Thailand with participants following seven programmes related to Holland's theory. The reasoning skills test was adopted from Jittachaun's test, and the problem solving ability test was adopted from real life problems and logical problems. The content validity, construct validity, and discriminant validity were reported, and reliability, Cronbach's Alpha, was .633. The academic ability was taken from the students' grade point average.

The most important finding is reasoning skills, and problem solving ability have some influences on each other approximately 30 percent; however, academic ability did not show much influence on the reasoning skills, and problem solving ability. This shows that academic achievement in university students in Thailand is not a good predictor of high levels of reasoning and problem solving ability. The other findings confirm the differences in those skills between students from different programmes and strengthen the case for using admission tests in Thailand for university admission. The thesis findings also reinforce the view that teaching and assessment in the Thai education system should be more involved with increasing/testing reasoning skills, and problem solving ability. In addition, the new admission system which requires different skills for different programmes is supported by this research result that different categories of programme and career need different skills.

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Chapter 1

Introduction

This thesis examines reasoning skills, problem solving ability, and academic ability from a cohort of final year university students following different academic programmes. This was the focus for the empirical work. Recent government initiatives in Thailand have emphasised the importance of developing reasoning skills and problem solving in the education system but as yet there have been few studies in Thailand that have examined the levels of students' skills in relation to their academic achievement. The students who were tested were drawn from different academic programmes which meant that the empirical research was also able to examine whether there were significant differences in the level of skills displayed by students in different programmes. Recently the university admission system in Thailand has introduced more centralised tests to help the admissions process. This research was therefore also able to examine whether testing students in relation to their potential for specific programmes (and at a future date their careers) is a sensible development.

There have been many changes to the university admission system in recent years with increasing use of centralised tests. During the last ten years in my role as a university lecturer in statistics I have noticed that there are some attempts to allocate the places in the universities to students effectively and fairly. The Thai government particularly has set up a new department for managing the admissions criteria and has introduced a test for this aim. The National Institute of Educational Testing Service (NIETS) was established on September 3, 2005, as a public organization. Its service extends from primary and secondary levels. It also prepares the examinations for university admissions in 2009 till now. Tests of reasoning have become more important in recent years in the admissions system in Thailand.

University admission is potentially a very broad topic and the focus of this thesis is more specifically on the use of tests of reasoning and problem solving and how these relate to choice of subject. But the admissions system has to be considered in the wider cultural context. So although the empirical focus is narrower, the broad context needs to be taken into account and this needs to be reflected not just in the literature review but in the background details of the education system in Thailand and the fact that the society is rapidly changing.

Many researchers start their work keeping the Thai motto in mind. ‘ใจเป็นนาย กายเป็นบ่าว’. It is one motto that I would like to introduce. The direct meaning is ‘thinking is the boss, body is the servant’. The inferential meaning would be thinking is of considerable importance for human beings. Normally human beings think nearly all the time, whether they intend to or not. Some think in a positive way, showing creativity, criticality and analytic skill, some think in a negative way, showing bias or prejudice. No matter who they are or what they do, human beings think and make decisions on a regular basis even in their day-to-day lives related to such questions as what they will wear today, what they will eat, how they will go to work or what are they going to do. Hence, thinking and decision making pervade everyone’s life. However, the challenges in the world are more complicated than just dealing with the basics, and humans have to confront decisions that are much more difficult and challenging than, for example, selecting what to wear. There are many ways in which human beings think and make decisions but which way is the most appropriate way for human to use in the different aspects of their life and in particular contexts? This apparently simple question is rather more complex than it seems at first.

Humans have used reasoning to work out what they should believe and how they should act since the earliest stages of human evolution. However, humans started to reflect on the reasoning process itself particularly in academic contexts. Johnson-Laird and Eldar Shafir (1993) indicated that reasoning and decision making are high level of thinking skills which have been investigated for the last thirty years. Kirwin (1995) concluded that reasoning is the cognitive process of looking for reasons for beliefs, conclusions, actions or feelings. Therefore, humans have the ability to engage in reasoning about their own reasoning.

At the present time, in the modern technological world, communications are sophisticated, and people have a variety of information to stimulate and inform their thinking. However, it is not just right information that is distributed in society. False and misleading information is also spread out to people too. People have to be able to analyze, discriminate and make good decisions on the basis of sound reasons. Education therefore has a crucial role to play in developing that ability.

In Thailand the word normally used for ‘analytical thinking’, ‘critical thinking’ and ‘reasoning skills’ is การคิดเชิงวิเคราะห์, การคิดอย่างมีวิจารณญาณ, and ทักษะการใช้เหตุผล. Many times these words are used with the same meaning. The words have a similar meaning but actually critical thinking is described as the rational examination of ideas, inferences,

principles, arguments, conclusions, issues, statements, beliefs and actions (Taylor, 2006). Meanwhile analytical thinking means the abstract separation of a whole into its constituent parts in order to study the parts and their relations (Thesaurus, 2010). On the other hand, reasoning skills, as Kirwin (1995) says, are the cognitive process of looking for reasons for beliefs, conclusions, actions or feelings. Thus, critical thinking and analytical thinking means carefully considering the problem, claim, question, or situation for the best solution. Reasoning skills, further than that, means carefully finding the best solution with the reasons or logic rather than a purely emotional response. Some researchers in Thailand have concentrated on the reasoning skills such as Jittachuen (1992) who studied the construction of a reasoning aptitude test for students in Thailand. He identified six kinds of reasoning aptitude; analogy, classification, inference, series, logical diagrams and analytical reasoning. With the identification of the six kinds of reasoning, the aptitude test is intended to inform students how much of each component they have and also to inform the teachers how much the school needs to help students to develop areas in which they may not have scored highly.

The importance of what we can call in general terms ‘reasoning’ is widely recognized. Meanwhile, the educational system in Thailand does not focus on reasoning skills as much as it could. The reason for this has to do with established traditions. There tends to be an emphasis on content knowledge, and students are not sufficiently encouraged to develop analytical and critical thinking skills, which are clearly demonstrated by their inability to complete a cloze test, or to grasp a thorough context. For example, they are often asked to respond to true or false questions in response to some content from books. The teachers will avoid introducing dialogue into the classroom or eliciting responses from the students because students are reluctant to respond as giving a wrong answer would be to lose face in the presence of one's peers. The cultural and educational traditions present a challenge.

Cheosokul (2002) summed up the problem about the education in Thailand. He suggested that Thai students have no courage to discuss any ideas with their teachers which is different from the other students from some other countries. And Thai culture expects Thai students to respect their teachers as semi gods. This feature seems the obstacle to the implementation of modern educational methods and the development of Thai students to focus more on reasoning in communication. Therefore, reasoning skills for Thai students tend to occur by accident or nature or not as a result of the specific teaching and training in the education system.

Further than that, in the last two years since 2009, Thai government has set up a new regulation for the selection of high school students into university. It is called ‘admission’ instead of the previous one, ‘entrance’. The new admission needs high school students to take a test in skills which are necessary for their career in the future; for example, students who would like to apply for engineering programme need to test reasoning skills, and problem solving ability.

As indicated above it can be argued that reasoning skills have become more important in the modern world because there is too much information, and too many choices that come into human’s minds. Those who have made the right decisions or act in a more reasonable way are likely to have less of a problem. Moreover, reasoning skills become more important for more practical reasons because many organizations test the candidates’ reasoning skills before employing them in their particular association. One example is, the Office of the Civil Service Commission (OCSC) which serves as the secretariat of the Civil Service Commission and is the central agency in charge of advising public sectors in managing human resource and protecting merit system practices of the civil service. Their responsibilities are to set up and develop recruitment and testing measures and serve as a recruitment and selection coordination centre for government agencies and state enterprises. They create reasoning tests to use as the first part of the whole process. And any candidate must pass this test first before going to the next step. Likewise, HSBC (2011, p.1) pronounce that

> ‘Whichever job vacancy you apply for, strong verbal and numerical reasoning skills are important. So, once your application passes our screening process, we'll ask you to complete verbal and numerical reasoning tests.’

Besides, to study in the USA, a Graduate Record Examinations (GRE) is needed. This is a general test that measures verbal reasoning, quantitative reasoning, critical thinking, and analytical writing skills that have been acquired over a long period of time and that are not related to any specific field of study (US embassy, 2011). In the light of this, it is perhaps strange that educational institutions in Thailand do not train students reasoning skills even though many institutes test them before recruiting them.

In Thailand, these skills have been much less studied compared to other countries; however, the Programme for International Student Assessment (PISA, 2000) studied how well students apply knowledge and skills to the work in their future life from nearly everywhere in the world (although not Thailand) and studied problem solving for tomorrow’s world. They found that students from a country that provides a

less advantaged background are less advantaged in school and are less advantaged in the way of solving problem. The interesting finding from PISA provides some insight into why some countries achieve better and more equitable learning outcomes than others.

In the light of this finding, there are some studies that focus on the differences of skills or ability between different countries. For example, Chalmers and Volet (1997) studied the Common Misconceptions about Students from South-East Asia Studying in Australia. They suggested that some South-East Asia students are different from Australian students because they may come from an educational context that is highly directed, structured and regulated by the teacher to find themselves in an educational context where self-direction, active participation and critical thinking are emphasised. And many of the students from South-East Asia share a common Chinese and Confucian heritage background which has traditionally emphasised the value of knowledge and respect for teachers. This suggestion was supported by Back and Barker (2002, p.64) indicating that 'students from Confucian background cultures feature a wealth of subtle and pervasive thinking, derived from socialisation patterns...' Therefore, the different values and belief systems will form the different characteristics and will be reflected in the approaches to learning. Back and Barker underlined that 'even if students from Confucian-background cultures reveal impatience with some traditional concepts, certain key issues are not dismissed as easily' (p. 64). Tantichuwet (2010) studied the patterns and characteristics of education administration in General Education Programs in the USA and Asian Countries. The samples were Harvard University, Stanford University, National University of Singapore, Lingnan University, Tokyo University and University of Malaya. The data were analysed by using content analysis. The result concluded that the objectives of universities in USA and Asia are the same; however, the curricula are different even in the same continent such as Harvard University and Stanford University. The pattern of education administration in the USA and Asian Countries was different. Moreover the regulations in General Education of each University are different. These are the differences of administration in education. On the one hand, the differences which come from students themselves can be noticed when they are studying in other countries.

Even though, there are some studies that have studied some skills in Thailand such as Tulananda and Roopnarine [2001] who observed some everyday activities of mothers and fathers with children for 2 hours in the home in 53 families residing in Chaing Mai Province in northern Thailand. They found that mothers were significantly

more likely to engage in basic care, general conversations, and educational activities; to praise; and to use commands and reasoning as forms of discipline with children than fathers. This is evidence that reasoning skills in Thailand may be developed from the family. However, there are a few studies that have studied the differences of skills or ability between Thai and other countries. Meanwhile Thailand is a country located in South-East Asia therefore Thailand can be assumed in a similar situation as the studies of Tantichuwet, PISA, Chalmers and Volet, and Back and Barker above. From those studies it can be summarised that skills or ability of Thai children might have less opportunity in school and less opportunity in the way of problem solving ability as PISA's recommendation; a country that has less advantaged background is less advantaged in school and also less advantaged in the way of solving problem. Also, Tantichuwet recommended that the pattern of education administration in the USA and Asian Countries was different. Also from the study of Chalmers and Volet the finding was presented that some South-East Asia students are different from Australia's student because many of the students from South-East Asia have traditionally emphasised the value of knowledge and respect for the person who taught them. Therefore their critical thinking skills may not be encouraged as much as other country student such as Australia's student. This difference was supported by Back and Barker, the different values and belief systems will form the different characteristics and will be reflected in the approaches to learning. This reading of the literature (with will be explored further in chapter two) led to the focus of my thesis. I decided to include gender as an additional focus as some studies such as Yenilmez et al. (2005) investigated the effect of gender and grade level on students' logical thinking abilities and found that 'results revealed a statistically significant effect of grade level and gender on reasoning ability'.

In addition, there is a need to investigate how reasoning skills influence other skills which are important and how these will help people to get ready to achieve a particular goal. Krulik and Rudnick (1993) believe that people who can solve problems easily usually use reasoning skills and intend to do their job very well. Moreover, they are excited to solve problems too. Learning ability and problem solving ability seem to be important and closely involved with reasoning skills. Therefore, this research will not only analyze reasoning skills factors but also examine influences on learning ability and problem solving ability too.

On the other hand, the need of reasoning skills for different careers may be different. It seems clear that artists and scientists need different levels of reasoning skills although some people might challenge that view. Holland (1996) took the view that the

choice of a vocation is an expression of personality and he set up the ‘theory of vocational choice’ which explains how personalities relate to the career choice. If students know how much reasoning skills the career needs, they could perhaps consider their career plan more efficiently. As will be explained in the methodology chapter, Holland’s theory was used to support the choice of programmes for this study.

One assumption, based on his theory, is that different careers need different amount of reasoning skills, and problem solving ability. And that informing people about the amount of these variables they need in different careers would be useful to them. The information may also be useful for high school students who are selecting their major and faculty in university which will lead to their career in the future. And also this result will help the educator to develop the curriculum to support students’ reasoning skills to confront with the real situation in this world.

Overall, the factors which influence human ability are a huge number. To focus and narrow the research, this research will examine some necessary skills for the new admission system especially reasoning skills and problem solving ability between different programmes. This will be related to the characteristics of the career which students will handle in the future. Furthermore, the influences of reasoning skills on problem solving ability, and on academic ability will be the core factors that educators should pay attention to because the students’ capability is the responsibility of the university.

The diagram (Figure 1.1) shows the specific focus of the thesis in relation to the broad background related to the history of education and attitudes to reasoning in Thailand and university admissions.

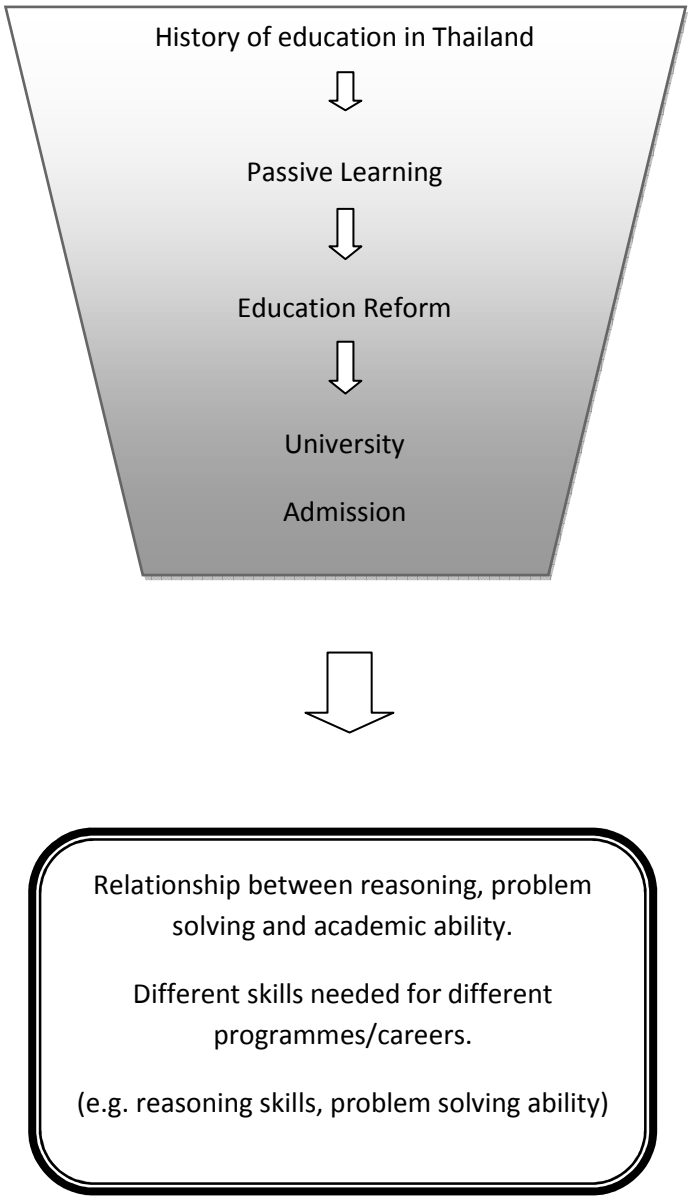


Figure 1.1 The relation to the broad background related to the history of education and attitudes to reasoning in Thailand and university admissions

The next table 1.1 summaries the areas of the research. Reasoning skills and problem solving ability were examined in relation to academic ability. In addition these variables were examined in cohorts of students from different academic programmes.

Table 1.1 The areas of the research

		Skills		
		Reasoning skills	Problem solving ability	Academic ability
Programmes	Marketing	…	…	…
	Accounting	…	…	…
	Engineering	…	…	…
	Chemistry	…	…	…
	Visual art	…	…	…
	Education + Psychology	…	…	…

This research has two main related objectives: to investigate the influences of academic ability on reasoning skills, and problem solving ability, and vice versa, and to examine whether students from different programmes displayed significant different levels of reasoning skills and problem solving skills. These objectives can be expressed in more detail as follows.

1. To compare students' reasoning skills, and problem solving ability between similar programmes (elementary educational programme and psychological programme; Holland's personality type).
2. To compare students' reasoning skills, and problem solving ability between different programmes.
3. To compare students' reasoning skills, and problem solving ability between different genders.
4. To examine the relationship between reasoning skills, problem solving ability, and academic ability in a cohort of final year university students.

The research objectives lead to the following operational research questions.

Research Questions

1. Are the students' reasoning skills and problem solving ability from the similar programme (Holland's personality type) the same?

2. Do the students' reasoning skills and problem solving ability from different programmes differ?

3. Do the students' reasoning skills and problem solving ability from different genders differ?

4. Do the reasoning skills, students' problem solving abilities and academic ability influence each other?

5. What understanding do students themselves have of reasoning skills, problem solving ability, and academic ability? This research is going to investigate the influences of reasoning skills, and problem solving ability on the learning. Therefore, students' opinions will show some aspects.

   This is primarily a quantitative study but a small amount of qualitative data was collected to address question 5.

Organization of the thesis

This thesis is divided into seven chapters. The first chapter is an introduction, providing background information about the reasoning skills especially in Thailand, the importance of reasoning skills, how they relate to academic ability and problem solving ability.

The second chapter reviews literature on reasoning skills, academic ability and problem solving ability. There will be focus on literature in Thailand as well as worldwide.

The third chapter discusses the methodologies of empirical research and research design. It will explain the sample groups, the tests and the approach to analysis, including validity and reliability of the tests. It will also contain a further element of literature review in that the theory of career choices used to support the choice of programmes will be discussed. The fourth chapter shows the results and explains the meaning of the results of quantitative data.

The fifth chapter shows the results and explains the meaning of the results of qualitative data.

The sixth chapter discusses the finding of the research.

The last chapter conducts an overview of the research, reviews the purposes, research finding and limitations, and makes conclusions.

Chapter 2

Literature review

This chapter will provide the basis and context for understanding the research by providing more information and reviewing literature on five main issues. Firstly, a brief overview of the history and development of education in Thailand, secondly, the concept of academic ability, thirdly, reasoning skills, fourthly, the problem solving ability, and finally, reason skills, problems solving and academic ability in other countries. Each of these topics has relevance to the overall focus of the thesis. This chapter will examine issues related to the testing of reasoning skills, examining the major approaches and theories of reasoning skills, problem solving ability, and academic ability.

The context in Thailand is important to this research especially the education system which is changing and evolving constantly. In order to understand the system as it appears to be in the beginning part of the 2000s, it is necessary to briefly review some of the important philosophical, ideological and political aspects of education over the last few centuries which have informed and influenced the educational system at this time. These include the culture and religious dimensions which have influenced the characteristics of students in important ways. The discussion in this chapter will illustrate how historical and cultural traditions have influenced the education approach and how these have impacted upon students' reasoning skills. It will also consider the relevance and importance of reasoning to issues of academic ability and problem solving ability. One of the main implications for this study is the issue of choice of programme at university and then subsequent career.

The Development of Education in Thailand: Historical Overview

The history of Thai education started when the king of Sukhothai, Ramkhamhaeng, created the Thai alphabet in 1283. He based it on Mon, Khmer and Southern Indian scripts which had existed before. During the Sukhothai period (1238-1378), education was provided by the Royal Institution of Instruction (Rajabundit) to members of the royal family and the nobility, while common people were taught by Buddhist monks.

The next era was Ayutthaya kingdom from 1350 to 1767. The basic structure of education for the princes, boys of noble birth, and commoners was adopted by the court and people of Ayutthaya and still prevailed in the early reigns of the Bangkok period. It is worth mentioning that during the reign of King Narai the Great, a book for the study of the Thai language entitled ‘Chindamani’ was written and remained in use up to King Chulalongkorn's reign (1868-1910). It is generally accepted as the first textbook of the Thai language. However, it should also be noted that such education was of an academic type as it did not provide for occupational training as such knowledge was generally passed on within the family or acquired through an apprenticeship.

The present period is the Bangkok period (1782 onwards). After the fall of Ayutthaya in 1767, and following a brief Thonburi period, the capital city of Bangkok was founded in 1728 by King Rama I (1782-1809), the first King of the present Chakri Dynasty. Modern technology in the form of the printing press entered Thailand with the coming of western missionaries and merchants in the mid 1800's. During the early Bangkok period, a number of treaties were concluded with foreign powers, mostly in the form of a Treaty of Friendship and Commerce.

Since English became the lingua franca of the Far East, King Rama IV realized that the kind of education provided by the monastery and the court was not adequate for future government officials. For this reason, he commanded that measures be taken to modernize the education of the country and a good knowledge of English would form a part of the new educational requirements, as it had become a necessary key to further knowledge as well as a channel of communication with foreigners.

The policy of educational modernization was further pursued by King Rama V (1868-1910). Recognizing the need for better-trained personnel in royal and governmental services, he opened a school in the palace to educate young princes and the sons of nobles in 1871. This was the first school in Thailand. Soon afterwards, King Rama V set up an English school in the palace to prepare princes and children who were relatives of the king for further studies abroad as well as a number of schools outside the palace for the education of commoners’ children.

Therefore, from the beginning of education in Thailand, boys were educated by the monks to prepare themselves for being monks, and also they educated boys who would like to study but did not want to be monks. The knowledge that they normally

learned was about Pali and Sanskrit language and religion, and girls learned how to cook for the family. The school at that time, therefore, was set up near the temple and normally they were the same name as the temple.

The educational system in Thailand was set up more formally in 1960 when compulsory school was applied to all seven year old children. However, only four years in school was compulsory at that time. After that students could choose to study further or quit the school. The compulsory education was expanded to six years in 1977 till now, 2011, and it was applied to six years old children. In addition, Thai government announced the free education for fifteen years, from the three years old kindergarten to high school, age 18. The structure is 3-6-3-3 year system that is in use today. The first 3 years is kindergarten, the second 6 years is primary school; this is compulsory, the third 3 years is junior high school, and the last 3 years is senior high school. As this result, students tend to study more than the six years that is compulsory at this moment. However, the subjects that they learn are general knowledge such as mathematics, languages, and sciences.

What are the general implications for this study for the way education has traditionally been conceived in Thailand? Because of the culture in Thailand, people had considerable respect for the monks and also the teachers, students were not allowed to challenge or argue with their teachers otherwise they would be punished by hitting at the bottom, hands or legs. Fortunately, Thai government does not allow students to be hit by the teacher anymore. However, the influence of the traditional approach to education can still be felt. Because of this culture, Dr Adith Cheosokul, a professor from Chulalongkorn University, Thailand, on September 1, 2002**,** said

> ‘Thai kids have no courage to question their teachers… . The Thais are usually silent in class. I think it’s the culture. Our students tend to uphold teachers as demi-gods.’

This idea is confirmed by a perception that is reinforced by the celebration of ‘wai khru’ day; this day is devoted to praising the teacher, in all schools and colleges shortly after the beginning of the new school year, where during a festive general assembly, the students kneel in front of the teachers on their knees and offer them gifts, usually of real or hand-crafted flowers. They thank them for imparting knowledge and wisdom.

While it is dangerous to over generalise about all teaching and learning, Thai culture and respect for Buddhism means that Thai students tend to be passive. This is confirmed by other writers. Wiriyachitra said Thai students should speak English better,

however, the difficulties are, for example, being too shy to speak English with classmates, and being passive learners (Wiriyachitra, 2010). Chairam et al. suggested that instruction in chemical kinetics in Thailand was often teacher-dominated at both the secondary school and undergraduate levels. Their work reported that to shift students from passive learning to more active was an enjoyable experience for the students (Chairam et al, 2009). Arguing with others or showing off usually cannot be accepted in Thai society. Thai students learn by receiving and through rote learning guided by teachers.

The author has studied in Thailand since primary school till master degree and had the chance to study in the UK for the doctoral degree. From direct experience of studying, the point of view that Thai students tend to be passive and less inspired to argue with others especially with the teacher is true. Arguing with the teacher is not considered polite and shows lack of respect which cannot be accepted in Thailand; however, in the UK, passive students tend to be boring for friends and teachers. British teachers prefer discussion in the classroom.

That style of learning has been influenced by the life style can be seen clearly when Nisbett, Peng, Choi, and Norenzayan (2001) have studied the influences of culture which affected the cognitive process, particularly, the difference between East Asians (Chinese, Japanese, and Korean) and Westerners (mainly European Americans). They found that there are differences existing in the areas of cognitive control, focus of attention, knowledge acquisition, attribution, prediction and postdiction, reasoning, cognitive styles, categorization, judgment, and problem solving. They concluded that the social systems have an influence on many elementary cognitive processes. The others studies (Norenzayan, Smith, Kim, & Nisbett, 2002; Norenzayan & Nisbett, 2000; Peng & Nisbett, 1999) have also produced similar conclusions. This finding has confirmed the Wiriyachitra's recommendation might be right. The difference in social systems between Eastern and Western cultures originated from the different developmental stage of their societies (Nisbett et al., 2001). With globalisation there is more influence from one culture to another and the dangers of stereotyping need to be recognised but it is important to acknowledge the influence of social context on teaching and learning.

As we know now the world has become narrower because of technology. Students in Thailand can see movies and news and so on from TV or the Internet. The other cultures especially Western and European culture has influenced Thai culture. This influence makes Thai people adjust to harmonize more with the world; such as,

communication, life style, and the way of thinking. At least, thinking and expression with reasoning need to be emphasised at this time. Fortunately, the importance of this concept drew a response from higher education in Thailand. They gave precedence to some skills, for example, problem solving ability and reasoning skills. They set up the new admission system by testing those skills before allocating places to students. While the learning procedure in Thailand traditionally does not place very much emphasis on encouraging students to develop skills in argument and reasoning, the new admissions system wants to test students' aptitude, reasoning skills, and other skills which are called aptitude tests, in order to provide them a place in the university. Standardised aptitude testing is a major procedure for selecting students for university.

Selecting the right programme to study in the university seems to be important for all high school students. On the one hand, Chulalongkorn University (2011) has a guidance project for high school students to select the suitable programme. They suggest that students should consider the following factors for selecting the appropriate programme.

1. Academic ability
2. Aptitude or special ability
3. Liking or interesting in that programme
4. Habit and personality
5. Health and physical character
6. Status of family economy
7. Aim and career in the future

However, on the other hand, Suan Dusit Poll (2005) has surveyed 3,143 Mathayom-6 students, final year high school students, (male = 1,652, female = 1,491) and found that the reasons they select the programme while applying to the university are:

reason1	Liking that programme	96.11%
reason2	Programme modernisation	79.22%
reason3	Easy to study	78.44%
reason4	Parent suggestion	72.00%
reason5	Teacher guide	68.00%

reason6	Popular programme	67.56%
reason7	Senior suggestion	61.22%
reason8	Friend suggestion	56.78%

Most reasons the students quote for selecting the programme seem inconsistent with the university recommendations. This may cause some wasted time and investments of both university and students. For example, some undergraduate students want to transfer and start to study another programme after one or two years have passed. Some graduate students work as they want and pick a profession that is totally different from their studying. For example, a student who has trained to be a general doctor then works as an announcer on television.

A major issue in students' life must be to select a programme to study in the university which is fulfilling for them and meaningful for their future career. How can they choose the right programme for themselves?

The history of admission in Thailand

The Central University Admissions System, CUAS (2011) recognises that primary and high school pupils, as recommend earlier, are basically studying knowledge provided that is general; for example, mathematics, languages, sciences. After Thai students have graduated senior high school, they normally apply to the university. The admission process uses criteria which students have to meet before getting a place in the university. The criteria must have efficiency and effectiveness. However, the admission criteria have been changed often within this half century.

Before 1961, each university considered places for students by themselves, in other words each university made its own decisions using its own criteria. In 1961, Kasetsart University and the University of Medicine cooperated to test candidates together, a process which was managed by the national education council. From 1962 all universities followed this example and managed to test the candidates together by creating the achievement test such as mathematics, sciences, and languages. The test was taken only once a year after the final term of education. However, the problem is some students had some accidents that prevented them taking the test on that day, therefore, they cannot be considered for a place in the university. As a result, students spent most of the time and more money for tutorials, and did not concentrate in

classroom learning. However, the main reason to make this change was to avoid a situation in which some students abandoned their places because they had received offers of places from several universities. This affected some universities who had too few students left and had to start the admission process again. From 1966 the cabinet, at that time, agreed with Chulalongkorn university's proposal to separate admission processes depending on each university so that each university was again responsible for its own admissions; however, that caused a big problem, the universities had to postpone the first academic term because the universities had to re-admit several times. In 1967, a year later, the cabinet agreed with the national education council to turn back to use the Central University Admissions System again with all universities using a centralised system. The centralised system in Thailand means all universities use the result from the same test which was organized by one organization of the government; National Education Council (NEC). After the NEC has received the result from the test, they will allocate the places for students. To some extent this differs from the centralised system in the UK which collects the application form from the students and distributes those forms to each University but leaves the Universities to make an independent decision. Then, from 1973 until now, the Ministry of University Affairs which later became a part of Ministry of education, has managed the admission system; however, the details have been changed time after time.

The university admissions process started to use standard tests with specific requirements for test scores in 2009. The newest regulation which the Central University Admissions System (CUAS) requires for this year; 2011, are:

1. GPAX (mean of last 6 terms GPA)	20 %
2. O-NET (Ordinary National Educational Test)	30 %
3. GAT (General Aptitude Test)	10 – 50 %
4. PAT (Professional Aptitude Test)	0 – 40 %

The percentage figures show the different elements that make up the final test (100%).

The percentages of GAT and PAT has an effect on each other; for example, the Japanese language programme needs 40% of GAT and 10% of PAT(79), (Japanese language) while English language programme needs 50% of GAT and does not need any PAT. The total percentages of GAT and PAT together are 50% in any programme. This will be discussed in more detail in chapter three.

Aptitude tests are worrying the students because many of them have not been taught the relevant skills in school before. The more understanding about the aptitude test the less worrying students become. The CUAS suggest that aptitude tests for GAT and PAT are mainly focused on the student's skills which may reflect their ability to study in those programmes or to work in those careers in the future. Reasoning skills and problem solving ability are some skills that the CUAS highlight for the test.

Overall, the approach to studying in Thailand has a long tradition that has developed for a long time which tends to be passive learning, and this reason affects the characteristics of learner. They seem not to be showing off their reasoning skills and other abilities; however, the new admission system would like to measure these abilities to manipulate places for the students in the university. With this situation, the academic ability, theory and their application for Thai education will be explained.

Academic Ability

'เด็กเหมือนผ้าขาว' is a Thai metaphor which means that children are innocent, they are empty, and so they can learn everything from everyone around them. The formal environment that children can learn most from is generally thought to be in the school. Not only the academic skills but also general life skills also can be learned from school. Everything the children learn when they are young, will affect them when they grow up. Kail (1990) has suggested that effective comprehension in adults has been attributed to a fully matured working memory and for children errors in comprehension can be attributed to an immature working memory capacity or as a functional limit reflecting a lack of automaticity in processing routines. This metaphor and Kail's suggestion show that anything related to learning especially when people are young, will influence people's life when they grow up. This research tries to find something that influences the academic ability of students so that improving of academic ability can be done in a more effective way. And because academic ability is quite important for the students, so it is one of the variables that this research will investigate. Therefore, academic ability will be addressed in more detail in this section.

Learning is often seen as a process of changing behaviour which occurs from practice or experience. It is not a process of changing behaviour as a result of illness or maturation but it comes from the development of different types of ability: motor skills, such as riding a bicycle, intellectual skills, such as reading and writing, and from the

development of attitudes and values. Of course negative attitudes such as bias may also be developed. Learning continues during the life of animals and a huge amount of learning happen in humans.

Bandura (1977) proposed that learning occurs through observation of others, or models. It has been suggested that this type of learning occurs when children are exposed to violence in the media. Holt (1983) said learning is a process of obtaining new knowledge, behavior, skills, values, preferences or understanding, and may involve combining different types of information. This is one aspect of the complexity of learning; that lots of different aspects are interrelated. Humans, animal or even some machines can learn. Human learning may occur as part of education or maturation and can be influenced by a variety of factors. Sometimes, it is very much assisted by motivation and whether the learner is goal oriented. Moreover, learning may occur as a result of training or classical conditioning, seen in many animal species, or as a result of more complex activities such as play, seen only in relatively intelligent animals and humans. Learning may occur consciously or without conscious awareness. So learning is a complex process.

Bloom's taxonomy is a well-known learning process. There are six categories of thinking skills which include (1) knowledge acquisition, (2) comprehension (3) application (4) analysis (5) synthesis and (6) evaluation (Bloom, 1956). The categories are listed in order of increasing difficulty with knowledge achievement which is considered to be the easiest up to evaluation which is normally thought of as the higher order thinking skill (Bloom, 1956). This taxonomy is widely referenced in Thailand. Actually Bloom's taxonomy is really helpful for the educators to manage the curriculum because the taxonomy guides the steps of behaviour which are needed. It describes the order of thinking from students to perform steps from lower thinking skills to higher thinking skills; as we can see from the six categories above. The purpose of education, normally, wants to improve students skills especially thinking skills but it is difficult to evaluate because the thought is seen as a form of subjective behaviour; however, Bloom indicated these six steps into objective behaviour which can be examined related to students' behaviour such as 'can student remember (X)?' used for examining step one; knowledge acquisition. And higher to the highest ability; evaluation, step six, the behaviour that students have to perform in this step will be the assessment ability. Many evaluation processes in Thailand follow the stages of Bloom's taxonomy. For example,

Sukhothai Thammathirat Open University uses this taxonomy as a pillar to build the examination tests.

Bloom's taxonomy can be seen as a description of thinking skills. Bloom declared there were six categories of thinking skills. Marzano et al. (1988) recommended there are eight skills that are important to learning process; (1) focusing skills, (2) information gathering skills, (3) remembering skills, (4) organizing skills, (5) analysing skills, (6) generating ideas, (7) integrating skills, and (8) evaluating skills. Both, Bloom's and Marzano's categories of thinking discuss the skills necessary for students to show critical thinking skills which are very important for students to learn with extensive understanding.

In psychology, a common definition of learning is a process of bringing together cognitive, emotional, and environmental influences and experiences for acquiring, enhancing, or making changes in one's knowledge, skills, values, and world views (Skinner, 1984). Learning can also be seen as a process which focuses on what happens when the learning occurs. So, explanations of learning process in theory have been given for a long time and take different forms.

The scientific investigation of the learning process was begun at the end of the 19th century by Ivan Pavlov in Russia and Edward Thorndike in the United States. Later psychologists manipulated the theory into three models. The first are widely used to explain changes in learned behaviour. Second highlight the establishment of relations between stimuli and responses, and the third emphasizes the establishment of cognitive structures.

The first model is classical conditioning. It was initially identified by Pavlov. He did experiments on a dog with a buzzer ring. At the same time when the dog had food, the buzzer rang. After several times, the dog salivated when the buzzer rang without food. Pavlov concluded that learning can be conditioned. The second type of learning, known as operant conditioning, was developed around the same time as Pavlov's theory by Thorndike, and later expanded upon by B. F. Skinner. Skinner did the experiment on a rat by pressing the bar for food. He found that rat can learn how to get food after it get food by accidentally pressing a bar. He explained that eventually the rat learned to press the bar to get food. Besides reinforcement, punishment produces avoidance behaviour, too. The third approach to learning is known as cognitive learning. Wolfgang said that more than trial-and-error, learning may occur by insight an idea which has been

supported by Edward Tolman who found that unrewarded rats learned the outline of a maze, and recognise it when it will get food. Tolman concluded that this is latent learning, and it has been suggested that the rats can develop cognitive maps of the maze that they were able to apply immediately when a reward was offered.

Hall et al. (2004, pp. 490 - 491) generalized learning approach from a wide range of sources. They concluded that there are two main ways in which students approach learning; the surface approach and the deep approach.

> 'A surface approach to learning is characterised by an intention to acquire only sufficient knowledge to complete the task or pass the subject. As such, the student relies on memorisation and reproduction of material and does not seek further connections, meaning, or the implications of what is learned.'

Meanwhile

> 'A deep approach to learning is characterised by a personal commitment to learning and an interest in the subject. The student approaches learning with the intention to understand and seek meaning and, consequently, searches for relationships among the material and interprets knowledge in the light of previous knowledge structures and experiences.'

However, at this time, the purpose of education has changed. Many universities have created the programmes to support the market force and for competition. Fieldhouse (1996, p. 3) supported that

> 'this ideological shift from self-help individualism to social collectivism began to change the nature of further education, adult education and higher education. This need for a greater social collectivism was enhanced by a growing fear of foreign competition and the increased recognition of the need for a skilled work-force. This led to the creation of the Technical Education Committees at the end of the 1880s which placed training firmly on the adult education agenda.'

The idea that there was the fear of foreign competition and the increased recognition of the need for a skilled work-force was agreed by Fagan. Fagan (2008) said the curriculum in Scotland is paying attention to 'enterprise in education' and 'education for work' in education policy and practice. He said it was the teacher's responsibility to put initiatives into place through devising context and choose resources to support learning. Therefore, the purpose of the education at this moment tends to emphasize how to produce skilled students to support the market forces. Some skills are expected such as reasoning skills. The development of critical thinking skills or

reasoning skills has established itself in education and it has become an important goal in education (Browne & Keeley-Vasudeva, 1992).

Overall, learning is an important process for everyone, especially for children. A small country located in the south east of Asia named Thailand has a history of education for a hundred years. The development of education in Thailand has received a lot of influence from Thai culture which relies on Buddhism. This factor brought Thai students to be passive students; however, with the globalization, the concept of education in Thailand changes gradually. At this time, some organization of education in Thailand started to bring the modern concepts such as 'student centred' and changed the way to admit students to the universities by testing their skills; reasoning skills, for example. This change needs students to be more active to propel the system. Therefore this research will seek to find out some knowledge which will throw light on whether the system is moving in a more effective direction. However, the strategies to manage learning for children and the education system depend on school or government policy.

Reasoning Skills

Continuing the above discussion, the teaching of reasoning is another issue that is interesting. In teaching students in school, there has been some attempt to change the way students think from cognitive lower-order skills to cognitive higher-order thinking skills. Ben-Chaim et al. (2000) suggested that higher-order thinking skill development is essential to bring about the evolution of students' intelligence and abilities into sensible actions, no matter what their specific future roles in society will be. And Barak et al. (2007) agree with Ben-Chaim; they indicated further that the school or teaching should include not only the creating of student's knowledge capabilities but also the abilities of thinking, making decisions, and problem solving. The reason why teaching should include these abilities in school was explained more clearly by Angelo.

> "Critical thinking does not simply develop as a result of maturation, but involves skills that are notoriously difficult to teach and learn, the problem as to how to raise students possible low critical thinking competency levels also deserves attention" (Angelo, 1995, p. 6).

Because reasoning does not develop purely by maturation, the same as academic ability that has been discussed in the previous section, this meant that there was more investigation about reasoning. Reasoning skills have been investigated from both psychologists and educators for a long time. In the early stage of investigation, they experimented on the animals instead of humans, and then applied to the theory. The past

several years have seen an increase in research on reasoning skills. For example, years ago Thorndike (1898, p.552) experimented on a cat to open a puzzle-box. He put a cat into a puzzle-box again and again. He found that the whole escaping behaviour of the cat changed. At first the cat's behaviour appeared to be random, or messy. Gradually, it became more orderly, more purposeful, and more efficient. However, he still cannot conclude that his theory about the puzzle-box experiments shows involvement with reasoning. As he said:

> 'the final disproof of the theory that the acts of the animals involve reasoning, comparison, and inference'

The developmental psychologists have been interested in reasoning skills because it is a productive area for studying conceptual formation and change, development of reasoning and problem solving. And the method that those skills work is necessary to manage a complex set of cognitive abilities. Kohler (1925) took a cognitive perspective when he explained the problem solving behaviour. He tried an experiment out on apes. He put an ape in a box and left a stick nearby for the ape, and hung a bunch of bananas high out of reach. After a minute the ape could get the banana by using the stick. He concluded that the ape used rationality to solve the problem. Recently, Schmitt and Fischer (2009) conducted an experiment on inferential reasoning in Baboons by choosing a can of food. The results showed that the Baboons can use inferential reasoning the same as Apes and other old world monkeys. From this point of knowledge, it can be estimated that reasoning skills can be taught and be developed not just in animals but also in human beings. The details will be addressed in the next section.

For humans, reasoning skills or the ability to represent and reason about objects and relations between anything depends on many methods and functions, including common-sense, query answering, natural-language processing, planning, and diagnosis problem solving. At the present time the number of objects and relations that need to be considered has increased dramatically, and the current real-world context requires reasoning mechanisms that can scale to hundreds and more objects and relations. Reasoning is defined by Kirwin (1995) as the cognitive process of looking for reasons for beliefs, conclusions, actions or feelings. Reasoning skills are instruments for making decisions using specific cognitive skills, assessing skills and thinking systematically or abstractly (Fischhoff, Crowell, & Kipke, 1999).

All of these researches confirmed that reasoning skills is important for life. So, investigation confirms that reasoning skills factors will improve reasoning skills in the right direction and more efficiently. Educators and educational psychologists can set a goal to determine the use of reasoning skills for improving learning and instruction in education. For this reason, developmental and educational researchers should give precedence to reasoning skills because the results of the research may indicate the better way to train the students to become more capable.

Can we teach reasoning?

To answer the question can we teach reasoning skills, Nisbett et al. (1987, p.238) report psychological studies recommending that

> 'even brief formal training in inferential rules may enhance their use for reasoning about everyday life events'.

They based their study on graduate programs students. The issue of reasoning skills becomes increasingly important during adolescence because teenagers are developing greater autonomy and encountering more choices independent of adults. The choices teenagers make may drastically affect not only their own lives, but the lives of others as well (Ganzel, 1999).

Nisbett et al. have an idea that people can use inferential rules, and that rules can be taught, for example by abstract means. However, they recommend that the rules which people use to solve everyday problem can be learned by training in statistics or even by students solving example problems in statistics. Including training in conditional logic, abstract logic, or even showing how to solve problem would work.

Overall, it is generally agreed that reasoning skills can be taught. However, they can also develop naturally or by accident or nature without specific teaching. The result of teaching may not always be controlled. There is also the issue of transferability of reasoning skills whether these have to be learned in context or whether they can be learned and applied more generally. For this issue, Harrison and Schunn (2004, p.1) experimented with the transfer of learning by assigning two groups of samples, the experienced person and the beginner, and then explored the application of general scientific reasoning skills. They concluded that:

> ‘Results indicate that at the graduate level, near-experts are able to apply general scientific reasoning skills across dissimilar domains, while novices still have difficulty with the transfer.’

Normally, transfer of learning is the application of skills, knowledge, or attitudes that were learned in one situation to another learning situation. Therefore the experienced person may get advantages from the previous experience and use it for the new situation. This can apply to studying in the university where they can teach or train their students reasoning skills; later students can apply it easier. This shows that the issue of transfer is not straightforward and varies with the experience and prior achievements of the learner.

The need for reasoning

One reason that humans especially at this time need reason is because of too much information distributed in this world and in a variety of ways, such as TV, radio, newspaper, or Internet. Not only is correct information given, incorrect information also comes to the public. It is a human responsibility to organize it, discriminate and make a good decision. Making decisions, even big or small, is often difficult (Shafir & Tversky, 1995) because of conflict and uncertainty related to specific situations and the associated emotions that are sometimes involved, including their experience. The idea is that rational decision making is a main ability and will enable people to reach the objective (Searle, 2004). Moreover, reasoning can be used for resolution of controversies. For example, academic controversy, which is the instructional use of intellectual conflict to encourage higher achievement and raise the quality of problem solving, decision making, critical thinking, reasoning, interpersonal relationships, and psychological health and wellbeing (Johnson, & Johnson, 1995). Some of the choices that human have to make include decisions that may include the career, whether or not to have sex or use contraceptives, whether or not to use alcohol, cigarettes, or other drugs, or whether or not to engage in violent or risky behaviours (Fischhoff et al., 1999; Ganzel, 1999). Concern about these risk behaviours, a programme involved with the development of reasoning skills is needed to help teenagers better protect themselves with effective decision making skills. Last but not least, reasoning not only applies to making decisions but also aims at stating truths (Johnson-Laird & Shafir, 1993).

Reasoning skills in relation to college students have been a focus of interest for a long time. Bill (1988) said that when teaching, students’ reason becomes more necessary and important; however, it is not an easy goal of higher education. He

recommended that when teaching students informal reasoning there is a need to provide students with a model of reasoning which clearly specifies the skills to be learnt such as manage the skills into the rough order depending on the function and complexity; direct instruction of reasoning very well; provide more practice on reasoning; and give precise feedback. The aim of this is to teach students to analyze, evaluate, and construct informal arguments. The research result of this study is intended to show evidence related to whether different types of career need different amounts of reasoning skills and different details. Therefore, the education system should prepare students for the appropriate programme. Spurrett (2005) confirmed that the classes containing variety of talent, skill and motivation will need more creativity and dedication in the teaching process; however, it is a risk for some students that if they are left behind, they may think ineffectively. He suggested that it will be better if the educators prepare the curriculum from the early stages of undergraduate which can gain the skill and motivation at critical reasoning more effectively. This good preparation could help the students to be successful in other courses and the future. Schmidt and Hunter (1998) concluded that reasoning tests are the best predictors of job performance. They also reported that reasoning tests can predict the effectiveness of staff training programmes, with staff who have higher levels of reasoning ability able to be trained more effectively than those who have lower levels of reasoning ability.

To sum up, reasoning skills are necessary in both school and work place. Students and workers who have higher reasoning skills seem to have more efficiency than the others. It would be better to prepare the curriculum to teach reasoning skills in school because students can develop and use it when they grow up.

Reasoning skills Test

A test is an instrument to examine something such as knowledge, skills, aptitude, and so on from the test taker. This research uses some tests, reasoning skills test, and problem ability test, to examine the participants' ability.

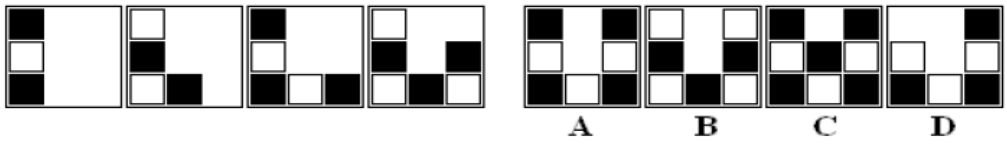
Reasoning tests were first developed by Alfred Binet, a French educationalist who published the first test of mental ability in 1905. He was interested in assessing the intellectual development of children, and eventually he developed the concept of mental age. The reasoning test was a part of an IQ test; the Stanford-Binet intelligence scales can be considered the first one of all modern intelligence assessments. The Stanford-Binet scales have been evolved through many revisions; the first one received analysis

by Lewis Terman in 1916. Terman produced ‘The Measurement of Intelligence: An Explanation of and a Complete Guide for the Use of the Stanford Revision and Extension of the Binet-Simon Intelligence Scale’. This handbook presented translations and adaptations of the French items, plus new items that he had developed and tested between 1904 and 1915 (Terman, 1916). Later this test was revised by many people such as Maud Merrill, in the 1950s, Thorndike, Hagen, and Sattler, in 1986.

The tests were criticised because some were thought to be culturally biased –that they favoured upper classes. Also they were thought to test just one type of intelligence - logic. Howard Gardner (Gardner & Hatch, 1989) viewed intelligence as multiple intelligences. He initially described seven types of intelligence: Spatial, Linguistic, Logical-mathematical, Bodily-kinesthetic, Musical, Interpersonal, and Intrapersonal, and these would allow seven ways to teach, rather than one. He defined the intelligence as 'the capacity to solve problems or to fashion products that are valued in one or more cultural setting'. This kind of thinking challenged some of the simple assumptions of the early test developers.

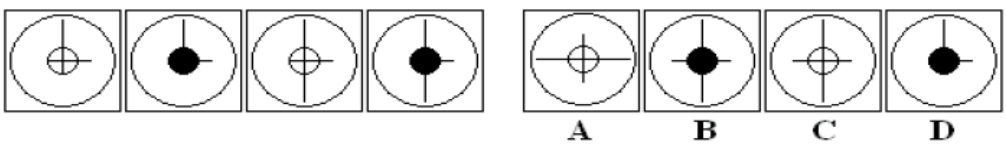
Reasoning skills test is a kind of psychological test which places emphasis on cognitive thinking and reasoning. Among many psychological tests, reasoning skills tests have been widely adopted. Newton and Bristoll (2010) conducted abstract reasoning test with diagrams, symbols and shapes instead of words and numbers. They suggested that the diagrams, symbols, and shapes do not involve ability in language and number which most reasoning test usually requires and may affect the test outcome. For example,

1) Which figure completes the series?



A B C D

2) Which figure completes the series?

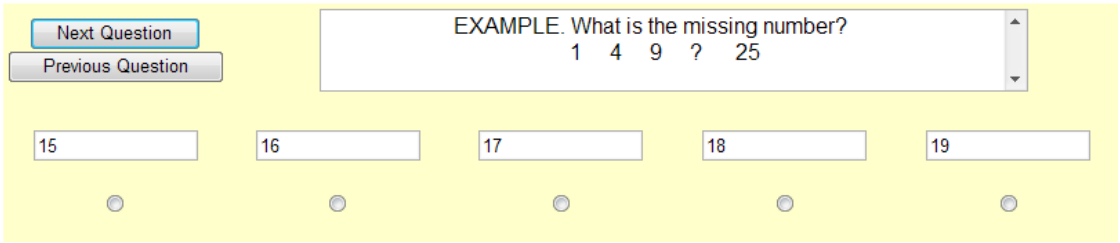


A B C D

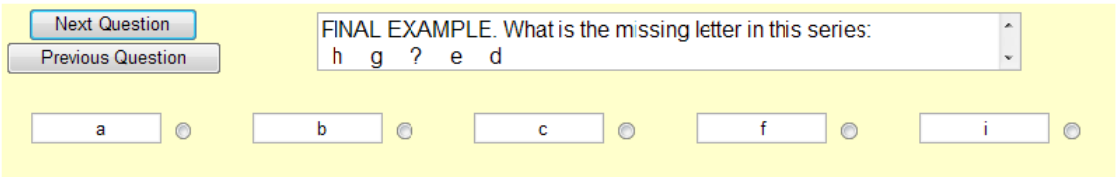
This example only requires understanding of language to follow the initial instruction but the test item itself is non-verbal.

The University of Kent Careers Advisory Service (2008) has produced four types of reasoning test. They use these tests and others for helping people to consider a suitable career which employers can use together with interviews, application forms, references, academic results and other selection methods.

1. Numerical reasoning; for example,

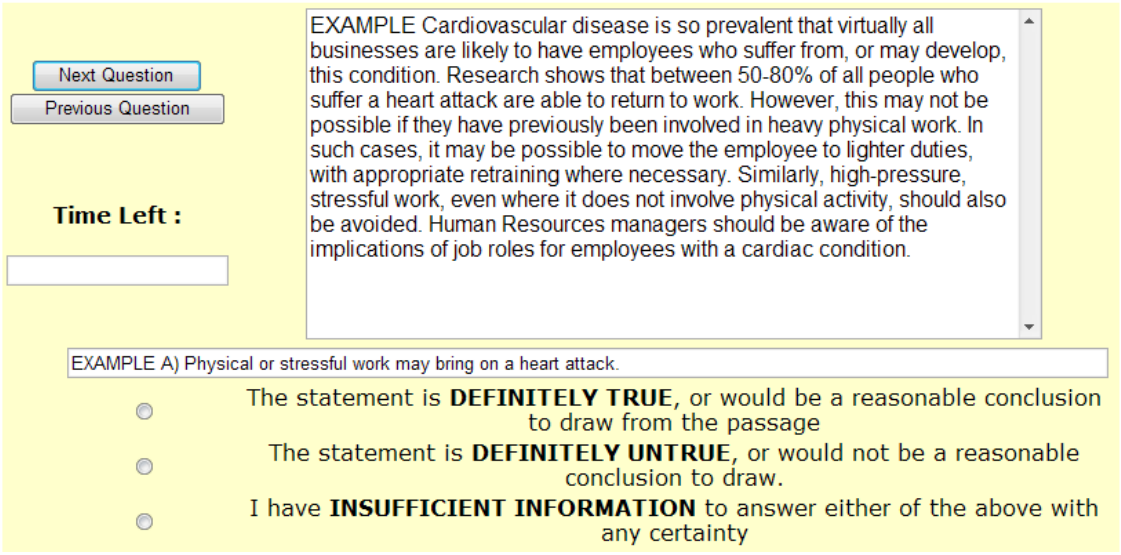


2. Logical reasoning; for example,



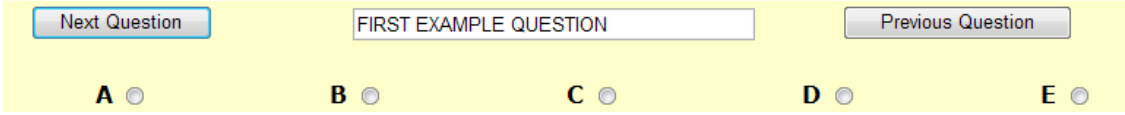
These two examples do not require language competence. They also do not require specific knowledge of any subject matter.

3. Verbal reasoning; for example,



This example does require language competence. Also it could be argued that knowledge of the subject matter could be an advantage when completing this item even though it is intended to test just reasoning.

4. Non-verbal reasoning; for example,



This item avoids any risk that what is being tested is more subject knowledge or verbal competence.

Procter and Gamble Company (2008) employed a reasoning test to help select the applicants to their company. They said reasoning skills are difficult to assess from resumes, application forms, or interviews alone. An applicant's score on reasoning test becomes one of the important qualifications considered in deciding whether or not to

hire an applicant. And it can predict the success of employees too. The test has three sections.

(1) Numerical Reasoning

Example question: A machine produces 100 units of product per minute. If 24 units of product are packed to the case, how many cases can be filled in one hour by the machine?

A. 125

B. 250

C. 500

D. 2,500

E. 6,000

Another advantage of these kinds of test items is that the answers are objective – no judgment is required in deciding whether an answer is right or wrong.

(2) Logic-based Reasoning

Example question: There are three central organizational functions to every product development project: marketing, design, and manufacturing. The marketing function consists of the interactions between the organization and the customers, which includes setting target prices and overseeing the launch and promotion of a new product. The design function determines the physical form of the product. This includes the engineering design, such as mechanical and electrical issues, as well as the industrial design, which includes aesthetics and user interfaces. The manufacturing function is responsible for designing and operating the system for producing the product. This function includes purchasing, distribution, and installation.

From the information given above, it can be validly concluded that:

A. An organizational function determines the physical form of a product if and only if it addresses mechanical and electrical issues.

B. There are product development projects in which the physical form of the product need not be determined before target prices are set.

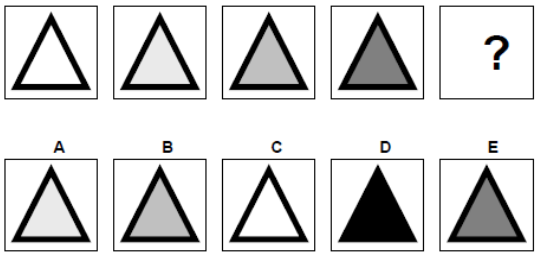
C. Whenever an organization is determining the physical form of a developing product, it is performing a design function.

D. There are at least some product development projects in which the marketing function does not set target prices or launch and promote the product.

This kind of item requires sophisticated reading skills but it is an item that might be more appropriate in vocational contexts.

(3) Figural Reasoning questions

EXAMPLE 1:



Hughes and Courteney (2010) have built both verbal reasoning test series and nonverbal reasoning test series for pupil's age between 7 years 3 months and 14 years 3 months. They explained that the tests help to assess pupils' future potential in that a pupil may acquire new concepts in a wide range of subjects including math, science, and design and technology.

The advantages and disadvantages of the verbal and nonverbal test can be discussed. First of all, the different characteristics of verbal and nonverbal test can be seen clearly in that verbal tests uses language as a tool to question and display the test, while nonverbal uses others, such as line, figure, objects, and drawing. The advantages of verbal tests are: easy to build and use, this means the test can be built in variety of way and make it more complicated but in the positive way whenever the test taker can read that language. And it is more accurate to the aim because language can explain the details clearly. The disadvantages of verbal tests will occur if the test taker cannot

understand the language clearly. On the other hand, with regard to the advantages of nonverbal test, Lohman explain that:

> 'The goals for using figural reasoning tests when selecting students for special programs for the gifted and talented are laudable: Measure abilities in a way that is fair to all students; increase the diversity of students who are included in programs for the gifted and talented; actively assist those who have not had the advantages of wealth or an immersion from birth in the English language.' (Lohman, 2005, p.112)

Moreover, another advantage is to avoid the language understanding problem. So, the test can be a standard test which can be used in any country. One of disadvantages is the ambiguity of the test in that the figure cannot be explained in more details and this may make the test taker misunderstand the test target.

Meanwhile, Jittachaun (1992) in Thailand has constructed a reasoning test in three formats, picture, language, and picture and language, with each test composed of the same questions and the same six factors; analogy, classification, inference, series, logical diagram, and analytical reasoning. The picture's reliability was .5694 and its validity was .4883. Meanwhile, the language's reliability was .7109 and its validity was .6218. Mixed picture and language's reliability was .7225 and its validity was .5507. All reliability and validity were significantly at the level of .01. Examples for the six factors of reasoning test are given below. They have been translated from Thai.

Analogy test

Instruction: item 1 – 4 please select a choice which relate to the first pair.

……

1. car : wheel → human : ?

   a. hand
   b. arm
   c. leg
   d. wheel
   e. eye

2. bird : worm → frog : ?

   a. insect
   b. watermelon
   c. grass
   d. ant
   e. millipede

Classification test

Instruction : item 5 – 8 please select a choice which differs.

……

5. a. mango
   b. pineapple
   c. tomato
   d. watermelon
   e. banana

6. a. frog
   b. kead (small green frog)
   c. turtle
   d. Tapapnum (shelled turtle-soft)
   e. eel

Inference Test

Instruction : item 9 – 12 please find the conclusion from assigned circumstance.

……

9. If ant has wings, he will plough.
   Ant has no wings, therefore…

   a. He sell flowers
   b. He plough
   c. He throws a net
   d. His rice field has no rice
   e. Cannot conclude

10. If he read books, he can be a soldier. He read book, therefore…..

    a. He is a teacher.
    b. He is a student.
    c. He writes books.
    d. He is a soldier.
    e. He holds a gun.

Series test

Instruction: item 13 – 16 please select a choice which can be the series.

……

13. seed, young plant, plant, ….

a. leaf
b. brunch
c. fruit
d. flower
e. seed

14. young plant, water, tree, ….

a. bloom
b. fruit
c. cut the tree
d. fruit selling
e. growing tree

Logical diagrams Test

Instruction: item 17 – 20 please select a diagram which shows relationship of assigned words.

……

17. sprout, tree, fruit

a. b. c. d. e.

Analytical reasoning Test

Instruction of analytical reasoning Test

Use statement 1 – 4 answer questions 21 - 24

1. 5 kg. turtle = chicken
2. bird lighter than fish which the same as pig
3. fish same as chicken or duck
4. two birds = a turtle

Instruction: use statement 1 – 4 answer questions 21 - 24.

……

21. Which one lighter than turtle?

a. chicken
b. bird
c. fish
d. pig
e. duck

22. How many kgs for 2 pigs?

a. 2 kgs
b. 4 kgs
c. 5 kgs
d. 10 kgs
e. 15 kgs

All of these tests are to test reasoning skills according to Jittachuan's concept which he has tested and confirmed as valid and reliable. This form of reasoning skills test which is widely used in Thailand will be used to test reasoning skills from the samples in this research.

In addition, investigating whether reasoning skills influences other attributes which are important will help people get ready to do something or to develop themselves. For example the 'Eleven Plus' examination was once used throughout the UK but is now only used in a number of counties and boroughs in England. This test established a tripartite system of education, with a technical, an academic and a

functional strand. The test was used to find out for which strand a child was most suited. The results of the test would be used to match a child's secondary school to their abilities and future career needs. The test tests a student's ability to solve problems using verbal reasoning, mathematics and nonverbal reasoning and English. However, the Eleven Plus was not used in some part of the UK. One reason comes from the teachers who disagreed with the test.

> 'A large majority of primary school teachers are unhappy with the 11-plus because many children who do not pass the selection test feel they have "failed" at an early age.' (BBC News, 2010)

And later, the Education Minister at that time, Caitríona Ruane, pronounced the ending of 11 plus tests. She believed that it would remove unnecessary pressure on children.

> 'I have repeatedly said that academic selection is both unnecessary and unjust. In many schools preparation for the transfer tests starts in P5 and this puts two years of pressure on nine and 10 year old children.' (Ruane, 2008)

Overall, designing a teaching strategy which has the aim of improving students' reasoning skills is not an easy job, even the teachers who have the most experience have difficulty with this (Tobin, Kahle, & Fraser, 1990). Lombard (2008, p.1038) made a good conclusion that:

> "the nurturing of critical thinking skills can be approached by multiple perspectives and if education institutions are taking the nurturing of student's critical thinking abilities seriously, collective intra-institutional interventions are necessary"

Problem Solving Ability

Another ability that this research gives precedence to is problem solving ability. This ability seems to be the result of thinking ability with efficiency of thought shown in the form of ability to solve the problem. It may be said that problem solving ability is the next step on from reasoning skills.

In Thailand, the importance of problem solving ability has been increasingly recognised. The Ministry of Education set up an education plan more precisely in 1999 to manage Thai education to become more child centred, and intended to increase attention to thinking skills and problem solving ability and other abilities of students. This plan prompted some researchers to study some issues that may relate to the plan.

For example, Suthisanon (2004) studied the creative thinking process of the students in Muthayomsuksa 4 (four grades, ten year old) and found that their creative thinking can increase with the imaginative practice. And Janpload (2007) studied the effects of using metacognitive strategies in organizing mathematics activities on mathematical problem solving ability and self-regulation in learning mathematics of eight grade students in Nakhonsrithammarat province, and she found that the students who learn by using metacognitive strategies had higher problem solving ability and self-regulation in learning than the students who learn by the normal strategy. There are various studies about the students' ability. On the one hand, the Institute for the Promotion of Teaching Science and Technology, 2011, suggested that the teacher should teach students to solve the problem by setting up the problem to them depending on their ability; easy problem for students who have low problem solving ability and increase the difficult level for students who have higher ability. Fortunately, this educational plan has continued to this year and the results of the plan have been applied in the new admission system in which now the problem solving ability is tested as a part of the admission examination. Problem solving ability is not only highlighted as important for students but also for those of working age too. Some companies train their employees in problem solving skills for their job efficiency. Polawanitch (2011) recommended that there are no best ways to solve the problem but people should understand the problem, the environment of the problem and people who get involved with that problem, and eventually make decisions. Eva (2010) explained more that the straightforward way to solve a problem is to remember how the problem was solved in the past.

Because problems are unavoidable, problem solving ability is important for human beings. Kamaruddin and Hazni (2010) recommended that the problem solving ability is very important especially for students. Students can improve their learning ability if the teachers teach them with the implementation of problem solving. Green (1966) said the investigation of problem solving became more important in the middle of the twentieth century due to the work of a few scientists such as Hall, Skinner, Newell, Simon and Shaw who were the first group who specifically sparked the idea of humans having problem solving ability; however, they emphasized solving problems on the computer because it is easier than working on humans. Newell, Simon and Shaw (1958) introduced a new theory of problem solving, based on concepts of information processing and computer programming. The nature of human problem solving methods has been studied by psychologists over the past hundred years. There are several methods of studying problem solving, including; introspection, behaviourism,

simulation and computer modelling, and experiment. Gestalt psychologists such as Kohler (1925) and Wertheimer (1945) have found that problem solving is integration of learned responses and they place emphasis on the true problem solving. Kohler observed that his apes could fit two sticks together in order to reach a banana outside the cage. He concluded that the apes had learned the relevant responses before they could put two sticks together into a complete problem solution.

More recently, the problem solving strategy has become the more interesting issue. There are many theorists who have defined the process of problem solving such as Goldstein and Levin, (1987) who defined the meaning of problem solving as a methodology of mental process to solve the problem and it is a higher order cognitive process which requires the modulation and control of more routine or fundamental skills. To make it become a more obvious process, Simon et al. (1986) defined that fixing agendas, setting goals, and designing actions are usually called problem solving, whereas evaluating and choosing, is usually called decision making. They classify problem solving and decision making separately. They focus on how humans respond when they are confronted with unfamiliar tasks. For example, his work on abstract problems like proving theorems in propositional logic and solving the Tower of Hanoi puzzle. The goal of this puzzle is to move all the discs from the left peg to the right peg. Only one disc may be moved at a time. A disc can be placed either on an empty peg or on top of a larger disc. (The picture shows below)

Figure 2.1 Tower of Hanoi puzzle

Beside this, VanGundy (1988) summarized the problem solving process in 5 stages. The first is pre-problem solving which is a process of determining a gap; if a gap remains between what is and what should be, determine a gap and if the problem gap is measurable, think about the available resources, and determine if the problem is in your responsibility. The second is problem definition and analysis which searches for and

analyses problem information. The third is generating ideas which search for readymade problem solutions. The fourth is evaluating and selecting ideas which search for information to evaluate the solutions. And the final is implementing the solutions when appropriate by using implementation techniques.

Other theorists generate the problem-solving process such as, Bank (1992*)* suggests six steps to problem solving; 1) Identifying the problem, 2) Identify the cause, 3) Generate Solutions, 4) Choose Solution, 5) Implement Solution, and 6) Evaluate Outcome. Buchanan and Boddy (1992) suggest nine stage model; 1) Identifying the problem, 2) Gather Data, 3) Analyse the data, 4) Generate Solutions, 5) Select Solutions, 6) Planning implementation, 7) Implement Solution, 8) Evaluate implementation and outcome, and 9) Continue to improve. However, Goswami and Pauen (2005) suggested that the successful solution is up to mapping the relational structure of the base problem to the target problem.

Additional information is provided by Piaget's theory who declared that problem solving ability is related to maturation. Piaget explains that young people can only solve easy problems which are not complicated and problem solving ability will increase when they grow up (Jones & Davidson, 1995). While Moss et al. (2007) studied the influence of open goals on the acquisition of problem-relevant information and they found that problem-relevant, or hint, presented implicitly in a second task in between attempts to solve the problem can aid problem solving. However, this finding cannot apply to the strategic behaviour of participants after they can solve the problem because most participants were not aware of the relationship.

On the other hand, Viskontas et al. (2004) showed evidence that challenged Piaget. They disputed the ability to integrate multiple relations and inhibit irrelevant stimuli the younger perform better than older people. Their experiment showed that younger adults performed very well but older adults perform poorly. They suggested that the observed decline may be explained by less attention and inhibitory functions in older adults. Likewise, Chrysikou (2006) argued that success in solving problems depends on the solver's ability to construct goal-derived categories. He explained that the categories will be formed to serve the goals during the instantiation of problem frames. His experiment showed that the effects of training in categories construction can be learnt without participants being explicitly informed; this is relevant to the issue of training and problem solving. On the one hand, it is hard not to believe that creativity can help people solve many common problems (Burroughs & Mick, 2004). Wang et al.

(2004) confirmed that creative thinking is a helpful resource that can be directed to the different strategy of problem solving process. In their study, Creative Problem Solving has its effects on the manager's idea to think more deeply to understand the problem situation and more correlated problem solving efforts.

Spiridonov (2006) conclude that most psychological research views the solution to solve the problem as a part of transformation of its content. The problem solver tries to find the way to solve the problem, such as calculate the number of things people will get, go to the point by using a particular set of lines, or determine when two trains will meet, and so on. However, the problem that researchers try to create is the type or forms of thinking that are already known.

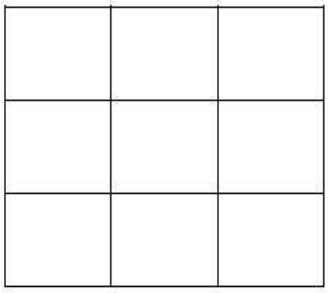
In human life, many components relevant to problem solving are found such as, perception, interest, aptitude, IQ, creative thinking, critical thinking, academic ability, and so on. When people want to know something new, they need learning ability. Perception can attain awareness or understanding of sensory information. Competence is the ability to perform a specific task, action or function successfully. Meanwhile motivation can activate goal-oriented behaviour. Their aptitudes help them do a certain kind of work at a certain level. An attitude can present an individual's degree of like or dislike for anything. And personality can organize a set of characteristics held by a person that uniquely influences his or her cognitions, motivations, and behaviours in various situations. A thing to make humans different from animal clearly is mental ability. In addition it can make humans different from each other too. Such as somebody can make decisions fast and correctly very easily but it may be harder for someone else, somebody can solve the problem easier than others. Not only mental ability but environment, baby care, personality, mindfulness, skills and so on also can make humans differ. There are many factors or skills that researchers try to investigate and manipulate for humans. IQ seems to be an obvious factor. Gene comes together with IQ. Personality is another popular factor that many researchers focus on. At the same time, reasoning skills are still important to study. These are not all equally relevant for all human beings. Something small for someone but may be big for others such as reasoning skills we should not omit.

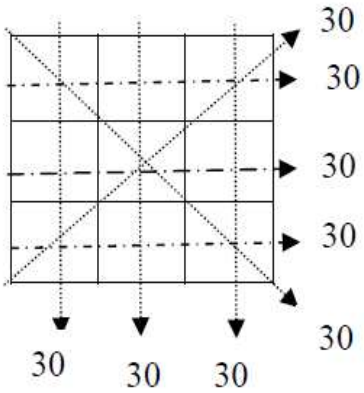
Problem solving ability test

The problem solving ability test was adapted from a variety of styles such as logical puzzle, real world problem, and mathematical puzzle.

Example 1: Please explain how you can across the river with only one animal at a time while you have a dog, a duck, and a chicken with you. You cannot let the dog stay with any animal without you.

Example 2: Please enter the number 6, 7, 8, 9, 10, 11, 12, 13, and 14 into the table each cell so that the summarization must be 30 in row, column and diagonal.





Overall, problem solving ability and reasoning skills seems to be important and relate to each other. People are recognizing their importance more. There are various theories and criticisms of them. Some suggested these abilities grow naturally as people grow up but some disagree; however, it is quite useful to train these abilities from a young age, and they will show their efficiency when people grow up.

Academic ability, reasoning skills, and problem solving ability in other countries

After examining the history of education in Thailand as well as general and specific information about reasoning skills, problem solving ability and academic ability in Thailand, now it would be helpful to view these skills in other countries.

Academic learning and teaching in Thailand seems to be passive and focuses on the achievement of students. Meanwhile other countries have their own patterns or characteristics. The patterns and characteristics usually differ in different cultures. This idea is supported by Tantichuwet (2010) who studied the patterns and characteristics of education administration in General Education Programs in the USA and Asian Countries. The samples were Harvard University, Stanford University, National University of Singapore, Lingnan University, Tokyo University and University of Malaya. The data were analysed by using content analysis. The following is a summary of her findings:

1. The objectives of general education in USA and Asian universities have the same characteristic focusing on students' broad knowledge than their major knowledge and abilities to make use of the knowledge in their everyday life.

2. The General Education curricula of Harvard University and University of Tokyo are core curricula. While, the General Education curriculum of Stanford University, National University of Singapore, Lingnan University and University of Malaya are Distribution Requirements.

3. Harvard University and Stanford University have the same pattern and use what she calls a 'Great Book Approach' course. She continues, 'Meanwhile, National University of Singapore, Lingnan University and University of Tokyo use Single Discipline and Compound course. University of Malaya uses Single Discipline, Compound course and Extraordinary course'.

4. The regulations associated with General Education in each University are different in terms of total credit, faculty and division.

While the objective of universities in USA and Asia are the same; however, the curricula are different even in the same continent such as Harvard University and Stanford University. The pattern of education administration in the USA and Asian Countries was different. Moreover the regulations in General Education of each University are different. These are the differences of administration in education. On the one hand, the differences which come from students themselves can be noticed when they are studying in other countries. Chalmers and Volet (1997) studied the Common Misconceptions about Students from South-East Asia Studying in Australia. They suggested that some foreign students are different from Australia's student because they may come from an educational context that is highly directed, structured and regulated by the teacher to find themselves in an educational context where self-direction, active participation and critical thinking are emphasised. And many of the students from South-East Asia share a common Chinese and Confucian heritage background which has traditionally emphasised the value of knowledge and respect for teachers. This suggestion was supported by Back and Barker (2002, p.64) indicating that 'students from Confucian background cultures feature a wealth of subtle and pervasive thinking, derived from socialisation patterns...'. Therefore, the different values and belief systems will form the different characteristics and will be reflected in the approaches to learning. Back and Barker underlined that 'even if students from Confucian-background cultures

reveal impatience with some traditional concepts, certain key issues are not dismissed as easily' (p. 64).

Eventually, the Programme for International Student Assessment (PISA, 2000) was set up to evaluate how well 15 year-old students were prepared to meet the challenges of today's societies. Students in each participating country were evaluated in three forms of literacy: reading, mathematical and scientific. The evaluations placed emphasis on how well students apply knowledge and skills to the work in the future life, rather than on the achievement of learning. PISA results suggest that school policy and schools themselves have an important role in controlling the impact of social disadvantage on student performance. Some school resource factors, school policies and classroom practices may make a significant difference to student performance. Both use of school resources from students and availability of specialist teachers can have an impact on student performance. The factors which related to the perceptions of teacher such as school climate, teacher morale and commitment, and school autonomy, appear to make a difference too. Lastly, there are some aspects of classroom practice show a positive relationship with student performance, such as teacher-student relations and the disciplinary climate in the classroom. The interesting recommendation from PISA is why some countries achieve better and more equitable learning outcomes than others.

Beyond illustration on the characteristics of student's learning ability, problem solving ability and reasoning skills can also be illustrated in term of the differences between countries. Reasoning skills are considered very important for students to use in learning and living in present society. In addition, reasoning skills and problem solving ability has also been considered as an important feature between Western academic models of study and non-Western or Confucian-based learning systems (Cadman, 2000). South-East Asian students in particular, are generally thought to be non-critical in academic issues and are considered to show a lack of ability to criticize and analyse with reasoning (Kutieleh & Egege, 2004). In other countries, McCannon et al. (2004) evaluated the utilization of clinical reasoning by students in the USA and Scotland. The results of this study indicated that the predominant form of clinical reasoning was procedural in nature (61%) followed by conditional reasoning (27%) and interactive reasoning (12%). Students in Scotland tended to use interactive reasoning more than the students in the USA. Later, Hanushek, and Woessmann (2009) investigated whether a causal interpretation of the robust association between cognitive skills and economic growth is appropriate and whether cross-country evidence supports a case for the

economic benefits of effective school policy. And they found the significant growth effects of cognitive skills when the institutional features of school systems have good management. And countries that improved their cognitive skills over time experienced relative increases in their growth paths.

Reasoning skills such as analytical reasoning, quantitative reasoning, analogical reasoning and combinatorial reasoning skills can be used to solve problems. Thus, a student needs to combine many different cognitive processes to solve a problem and the PISA (2003) studied Problem Solving for Tomorrow's World as well as the study of three literacy forms: reading, mathematical and scientific. They found that students from a country that has less advantaged background is less advantaged in school and also less advantaged in the way of solving problem. Countries should be aware that social background has such a strong effect not just on curricular outcomes but also on acquisition of general skills. Many studies are indicating the importance of employees acquiring problem solving skills in the modern workplace.

There have been some studies in different countries that examine the relationship between academic ability, reasoning skills, and problem solving ability. For example, Yenilmez et al. (2005, p.219) investigated the effect of gender and grade level on students' logical thinking abilities. They found that 'results revealed a statistically significant effect of grade level and gender on reasoning ability'.

Bouhnik and Giat (2009) developed a high school course designed to provide students with applied logical tools. After they did the experiment teaching, they found a significant improvement in the students' critical reading skills.

Weiping et al. (2011, p.551) concluded that 'specific attention to the development of children's thinking, even of a very modest intensity, can have far-reaching and cost-effective positive effects on their learning'.

Croker and Buchanan (2011, p.409) stated that 'scientific thinking and reasoning skills underpin achievement in science education and the development of these skills is fundamental to becoming a scientifically literate adult'.

Anand et al. (2011, p.961) suggest that 'top-down strategy-based gist reasoning training significantly improved abstraction ability, a skill relevant to everyday life, as well as generalized to untrained measures of executive function including concept abstraction, cognitive switching, and verbal fluency'.

Mienaltowski (2011) examined the influence that aging has on everyday functioning in reasoning and problem solving. 'Everyday problem solving involves examining the solutions that individuals generate when faced with problems that take place in their everyday experiences…Across the life span, research has demonstrated divergent patterns of change in performance based on the type of everyday problems used as well as based on the way that problem-solving efficacy is operationally defined'(abstract).

Shokoohi-Yekta et al. (2011, p.85) indicated that 'teaching problem-solving skills to parents had a positive influence on a number of dimensions of parenting as measured by the Parent Child Relationship Inventory'.

There are many studies emphasis on academic ability, reasoning skills, and problem solving ability; many of these studies show a relationship between academic ability and the other skills. However, there have not been any studies in Thailand that look at this relationship.

Conclusion

Thailand has had an educational system for more than a hundred years. Due to Thai culture, the education system has primarily been focused on passive learning. This has traditionally causes Thai students to become passive compared to western culture. In recent years there has been more emphasis on skills of reasoning and problem solving ability by the government but are these skills reflected in the academic results of students in university? More recently, the new admission system for a place in the university tests students in skills, such as reasoning skills and problem solving ability, as criteria to admit them. The reason is to select students who have the aptitude in that area to study in that programme. There are also reforms in Thailand that want to emphasise reasoning and problem solving more. This review has considered issues of academic ability, problem solving and reasoning. There are differences of opinion but there seems to be consensus that reason can and should be taught and can be tested in a meaningful way.

The literature reviewed showed that in a number of countries academic ability is a good predictor of reasoning skills and problem solving. However, there seems to be no research conducted in Thailand that examines the relationship between academic ability, reasoning and problem solving among higher education students. This is where I hope that my study will fill a gap. By examining the relationship between these variables the research may be able to determine to what degree the government

emphasis on these skills is having an effect in universities. This study does not propose to compare the levels of reasoning between Thai students and those from other countries. This would be a helpful comparison but it is beyond the scope of this study and no similar comparisons were found in the literature (it would be a useful area for further study). However, comparing these skills to academic achievement will yield useful information even without the international dimension.

The other aspect of this research is to compare the levels of reasoning skills and problem solving ability from students following different programmes. Therefore, from this point, this research would like to find out how different they are, and present a rank order which will show the amount of skills in each programme, then sort them. The results can be applied to career selection, for example, someone who would like to be an engineer may consider how much reasoning skills or problem solving ability s/he has. This will also potentially support admission into the university.

Chapter 3

Methodology

This chapter will describe the research questions set and hypotheses for this study, and explain the research instruments employed to answer the research questions set, and the research methodology. Tests and interviews were used to collect the data. In order to explain the choice of programmes for this research there will be an explanation of Holland's theory of career choice. There will also be details of how the research questions and hypotheses were established and an explanation of the thinking behind each of the hypotheses and how these relate to the available literature.

3.1 Research questions

This research has two main related objectives: to investigate the influences of academic ability on reasoning skills, and problem solving ability, and vice versa, and to examine whether students from different programmes displayed significant different levels of reasoning skills and problem solving skills. The first objective was established after reviewing the history of education in Thailand and some of more current literature that has expressed concern about the passive approach to learning and the lack of sufficient attention to reasoning and problem solving amongst learners. As seen in the last chapter in several countries, academic ability is seen as a good predictor of levels of reasoning and problem solving. In Thailand the government has in recent years sought to encourage the education system to place more emphasis on these skills. The assumption of this research is that data on the correlation between academic ability and such skills would be useful. In addition the admissions system to university has changed in recent years with more use of centralised tests for students to gain admittance to different programmes. The empirical research therefore also sought to gain data related to the different programmes, specifically whether there was a significant difference in the scores in problem solving and reasoning amongst students studying different programmes. It was thought that data of this kind would be helpful to confirm whether the admissions system is moving in the right direction or not. In addition data was sought to establish whether there were significant gender differences in reasoning and problem solving; data of this kind would also be helpful. Valentine (1998) noted women have the characteristic of being emotional and sensitive to function outside of domestic roles. Gilligan (1993) recommended that women tend to view work as a network of

relationships while men view work as a logical or task oriented fashion with the implication that males would score higher on reasoning tests.

In order the chose the six programmes for the research Holland's theory of career choice was used. This theory will be explained in more detail later in this chapter but a brief explanation here will be useful for understanding the research questions and hypotheses more clearly. Holland took the view that an individual's personality can reflect his occupational choice. Holland's six types or themes are Realistic, Investigative, Artistic, Social, Enterprising, and Conventional and these can be related to specific academic programmes. By relating the choice of programme to Holland's theory it was hoped to maximise the possibility of differences in scores in reasoning and problem solving.

In order to operationalize the research, the following specific questions and hypotheses were formulated.

(1) Are the students' reasoning skills and problem solving ability from similar programme (same career personalities) the same?

The first two hypotheses were related to Holland's theory. The two academic programmes of education and psychology are assigned by his theory to one 'career personality' type (social). If Holland's designation is correct then there should be no significant differences in reasoning and problem solving amongst the student from these programmes.

Hypothesis 1:

Students from the similar programmes have the same level of reasoning skills.

Hypothesis 2:

Students from the similar programmes have the same level of problem solving ability.

(2) Do the students' reasoning skills and problem solving ability from different programmes differ?

Hypothesis 3 and 4 were related to the assumption that students from different programmes might have different levels of reasoning and problem solving skills. If Holland's theory is correct and programmes can be related to 'types' then it is a reasonable assumption that such scores might be different. However, Holland represented his types in a diagram as a hexagon (see below for more details). In other

words ‘artistic’ and ‘social’ types are closer to each other and more distant from ‘conventional’ and ‘realistic’. On this basis it would be safe to assume that there might be significant differences between some but not all programmes. At this stage the hypotheses were expressed in simple terms to see if there were any significant differences with more detailed analysis coming in the post hoc comparisons.

Hypothesis 3:

Students from different programmes have different levels of reasoning skills.

Hypothesis 4:

Students from different programmes have different levels of problem solving ability.

(3) Do the students’ reasoning skills and problem solving ability from different genders differ?

Hypotheses 5 and 6 were related to gender. The assumption from some of the literature is that men are more likely to score highly on tests of reasoning and problem solving skills. However, it is wrong to assume that this will be true in all contexts and all cultures. Nor is it safe to attribute simple causes even if significant differences are found. It was decided therefor to express these hypotheses in a straightforward way to establish whether there were any significant differences in the scores between males and females.

Hypothesis 5:

Male and female have different reasoning skills.

Hypothesis 6:

Male and female have different problem solving ability.

(4) Do the reasoning skills, students’ problem solving abilities and academic ability influence each other?

Hypotheses 7, 8, and 9 were related to the first research objective which was particularly concerned to establish whether a high or low academic ability as reflected in the students grades is a good indicator of likely achievement in reasoning and problem solving. Also although the literature distinguished between reasoning and problem solving there is clearly an overlap between them. The intention here was to establish the influences between reasoning skills, students’ problem solving abilities and academic ability.

Hypothesis 7:

The reasoning skills were influenced from students' problem solving abilities and academic ability.

Hypothesis 8:

The students' problem solving ability was influenced from reasoning skills and academic ability.

Hypothesis 9:

The academic ability was influenced from students' problem solving abilities and reasoning skills.

(5) What understanding do students themselves have of reasoning skills, problem solving ability, and academic ability?

Table 3.1 The purposes of research questions

Research question	Specific purpose	Relationship to broad aim.
(1) Are the students' reasoning skills and problem solving ability from the similar programme the same?	Would like to know if these skills can be generalised into the same group following the theory of Holland.	This result can apply to setting up the criteria to the same group of programmes which are recommended by Holland's theory in the university admission.
(2) Do the students' reasoning skills and problem solving ability from different programmes differ?	Would like to know if these skills differ between different groups following the theory of Holland.	This result can apply for setting up the criteria to the different group of programmes which were recommended by Holland's theory in the university admission.
(3) Do the students' reasoning skills and problem solving ability from different genders differ?	Would like to know if these skills differ between genders.	In the detail, boys and girls may need to be trained in different way in Thailand.
(4) Do the reasoning skills, students' problem solving abilities and academic ability influence each other?	Would like to find out the influences between these skills.	The result can remind the educator to think about the aim of teaching and the way to teach in Thai society.
(5) What understanding do students themselves have of reasoning skills, problem solving ability, and academic ability?	Would like to find out more information to fill in some gaps in the quantitative data.	Some students' ideas may be useful for the educator to think about.

After the preliminary analysis a comparison was conducted to compare the students reasoning and problem solving in relation to their different programme choices. On the basis of the literature and in particular Holland's theory and hexagon typology the hypothesis for the comparisons was students from engineering, chemistry, marketing programmes would score more highly in reasoning than students from art, education, psychology, and students from education, chemistry, marketing programmes would score more highly in problem solving ability than art, education, psychology.

The choice of academic programmes for the research

In order to conduct the empirical research I needed to choose subjects from different academic programmes. One of the objectives of the research was to examine whether the level of reasoning skills and problem solving ability differed significantly in students from different academic programmes. In order to strengthen the likelihood of such differences being determined, I thought it would be helpful not to choose the programmes on a purely random basis but according to a theory that is based on the view that different academic programmes are related to different 'career personalities'. This theory was advanced by Holland and needs more detailed discussion.

Holland developed a classification system based on each individual and their interaction with their work environment. John Holland's impact was vital to the practice of career counseling, since it provided a way to evaluate the person/environment fit (Weinrach, 1996). The theory is based on a hexagon typology (See Figure 3.1).

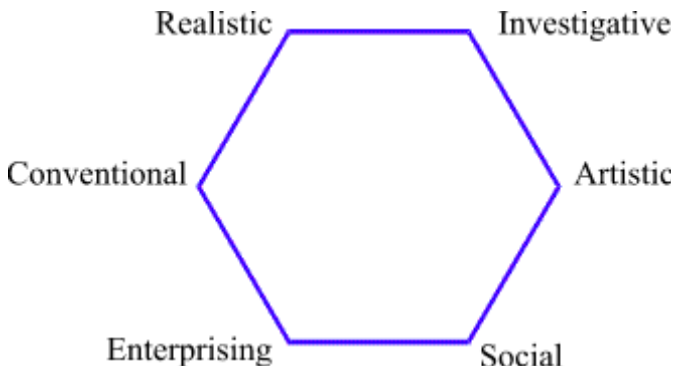


Figure 3.1 Holland's Hexagon Typology

It is generally the case that most people think carefully about their own individual suitability for a particular job, occupation, or career goal. Such a choice may

be short term or permanent, and may be only an intention or inspiration or may be put into action. In 1927 the systematic assessment of vocational choice began when Strong first published the Strong Vocational Interest Bank for Men. After that in 1934 Kuder first introduced the Kuder Preference Record, and then 1959 John Holland proposed the career choice which is an expression of personality and interest. He invented the Vocational Preference Inventory (VPI), and Self-Directed Search (SDS) that can measure personality type and interest. To understand more about the career choices, the theories of career development, such as Holland's theory of vocational choice, focuses on vocational choice as a central construct. Holland's Theory four working assumptions constitute the heart of the theory (Holland, 1973):

> '1. In our culture, most persons can be categorized as one of six types: realistic, investigative, artistic, social, enterprising, or conventional. (The more closely a person resembles a particular type, the more likely he is to exhibit the personal traits and behaviours associated with that type)' (P.2)
>
> '2. There are six kinds of environments: realistic, investigative, artistic, social, enterprising or conventional. Each environment is dominated by a given type of personality, and each environment is typified by physical settings posing special problems and stresses.' (P.3)
>
> '3. People search for environments that will let them exercise their skills and abilities, express their attitudes and values, and take on agreeable problems and roles.' (P.4)
>
> '4. A person's behaviour is determined by an interaction between his personality and the characteristics of his environment. . . (The pairing of personality types and environments) leads to forecast some of the outcomes of such a pairing. Such outcomes include choice of vocation, achievement, personal competence, and educational and social behaviour.' (P.4)

The first publication of his theory was in 1959 in the Journal of Counselling Psychology. Within seven years after that Holland and others had conducted some researches to extend his theory and the results were published in 1992 in The Psychology of Vocational Choice: A Theory of Personality Types and Model Environment. The first revision focused on the environment and methods for measuring the effect of work environments.

After 1966, the researches which were conducted based on Holland's theory focused on the high school students of above average intelligence. Researchers recognized this point as a definite limitation (Walsh, & Osipow, 1983). And the most well-known revision of Holland's theory was displayed in 1973 when it incorporated the use of the hexagon model.

In 1970s, Holland had to explain his theory as it related differently to males and females who might need a different format and he sought to solve that problem a few years later. He collected the data from 43,391 participants supported the person-fit

theory and he published the results in his 1973 book (Gottfredson, 1999). Despite the fact that Holland began writing his theory in the late 1960s, David Cambell became interested in Holland's theory and investigated some basic occupational patterns. Later they worked together and created the application of Holland's theory to interest inventory (Cambell & Holland, 1972). In 1997, Holland introduced the idea of psychological characteristics in term of 'beliefs' which represented their self and their environment. This idea emphasized the classification of the work environment. Holland and Gottfredson (1996) used Position Classification Inventory to integrate work classifications with individual personality classification. His theory presented the use of career development with a few or without counselor intervention. The theory had simplified the career development process so that each individual could use it by themselves. It was very useful for the counselors in their job (Holland, Powell, & Fritzsche, 1994).

Holland expanded the conceptual idea that people see themselves in relationship to their work. An individual's personality can be reflective of his/her occupational choice. Holland's six types or themes are Realistic, Investigative, Artistic, Social, Enterprising, and Conventional, sometimes called the RIASEC theory of personality. Therefore, Dr. John Holland's theory of career development (1959, 1966, 1973, 1985(a), 1985(b), 1996, and 1997) is a developmental theory based on the fit of an individual's personality to the work environment. We will consider each one in turn as Holland's inventory will be a central aspect of this study.

The Realistic (R) personality type is the type of person who prefers to work with something realistic, can understand easily, can work with figures and drawings; they are less inclined to engage in work that is involved with other people. The type of work they tend to prefer are agriculture, archaeology, architect, astronaut, athlete, chef, driver, electrical engineering, engineer, fire-fighter, gardener, information technology, instructional technology, martial arts, mechanic/automobiles, mechanical engineering, paramedic, physical therapy, pilot, veterinarian, and police officer.

The usual problem solving style associated with this type is as follows: prefers concrete, practical, and structured solutions or strategies as opposed to clerical, scholarly, or imaginative activities.

The Investigative (I) personality type is a type of person who enjoys puzzles and challenges that require the use of the intellect. They also enjoy learning and they enjoy

courses in math, physics, chemistry, biology, geology and other sciences. They are not likely to enjoy supervising other people or dealing directly with personal problems, but may enjoy searching for solutions to psychological problems. The type of work they tend to prefer are jobs such as actuary, computer science, economist, finance, lawyer, mathematics, pharmacy, professor, psychologist, psychiatrist, science, statistics and surgeon

The relevant problem solving style is as follows: interested in challenging problems, relies on thinking, collecting information, careful analysis, objective data, and related scholarly practices, and does not take a great interest in personal feelings or social environment.

The Artistic (A) personality type is the type of person who likes the opportunity to express himself or herself in a free and unsystematic way. They are likely to want to improve their ability in language, art, music or writing. Originality and creativity are particularly important. A pure Artistic type would dislike technical writing and prefer writing fiction or poetry. The type of jobs they might prefer are actor/performance, animation, art therapy, artist, author/ poet, dance therapy, expressive therapy, graphic designer, library and information science, music therapy, musician, and painter.

The relevant problem solving style is as follows: understands problems in artistic context, use artistic talents and personal traits dominate the problem solving process.

The Social (S)) personality type is a type of person who is interested in helping people through teaching, helping with personal or vocational problems, or providing personal services. Social people enjoy solving problems through discussion and teamwork. Social people tend to avoid working with machines. They seek out environments where they can use verbal skills and social skills. The type of work they prefer are jobs such as elementary school teacher, special education teacher, marriage counsellor, counselling psychologist, speech therapist, school principal, nurse, and social worker.

The relevant problem solving style is as follows: understands problem in a social context and uses human relationships to solve the problem.

The Enterprising (E) personality type is the type of person who appears more self-confident than they feel. Some enterprising people may be quite open about their goal to accomplish wealth, whereas others may be very reluctant to admit to a goal they see as socially inappropriate. Like Social types, they may be very verbal. Unlike Social types, enterprising people will value convincing and persuading others rather than helping others. The type of the jobs they prefer such as sales work, buying, business management, restaurant management, politics, stock market, marketing/advertising, insurance, real estate, and lobbying. All of these environments provide the opportunity for power, wealth and status.

Problem solving style is as follows: understands problem in an enterprising context, so problems are often viewed in social influence terms.

The Conventional (C) personality type is a type of person who values money, being dependable, and the ability to follow rules and orders. These people prefer being in control of situations and having clear and specific requests. Competencies that are needed to work well in the conventional environment are clerical skills, ability to organize, dependability, and ability to follow directions. The type of jobs they prefer are accountant, actuary, administration, academic administration, banking/ investment bank, clerk, copy editing, instructional technology, payroll, proof-reader, receptionist, retail, and technical writer.

Problem solving style is as follows: follows rules, practices, and procedures, looking for authorities to solve and needs advice and counsel. Has difficulty with the complicated problem or synthesizing data from diverse sources.

It was the association of specific programmes with the concept of career personalities that helped me to determine which programmes to choose for this research.

Holland (1997) explained more about his theory that people will tend to search for environments where they can exercise their skills and abilities to show their attitudes and values, and take on agreeable problems and rules. For example, realistic types will search for realistic environment, artistic types will search for artistic environment. His view is that a person’s personality can predict the environment which that person would like to be in. Holland’s theory assumed that the choice of a vocation or a college major is an expression of personality and that most people can be classified as one of six primary personality types (Realistic, Investigative, Artistic, Social, Enterprising, and

Conventional). From this idea, Holland's theory is really useful for careers counselor to give guidance to the students before applying to the university or going to work. Spokane, Meir, and Catalano (2000) said working in an occupation that is suited to one's own interest can lead to more satisfaction and success in work.

Even though Holland theory has many research studies which support it; however, there are some challenges to the Holland model. For example, the hexagon model has a restricted range of measurement. Hunter (1986) had some questions about the intelligence and special abilities which affect job satisfaction. When Holland's theory is used, the homogenous samples are measured, special abilities do not induce to the predictive validity. Warr (1987) reported that there are some common elements found within a desired work environment. These elements cannot be predicted, such as opportunity for advancement, monetary incentive, positive feedback, personal respect, and the implied notion of independence and control. However, Prediger (1989) found that when using variety group of samples, the homogenous and individual abilities did account for unique variances. Prediger supports Holland's model that the hexagon approximates reality when applied to measures of work relevant interest.

Later, Dawis (1991) recommended that job satisfaction consists of intrinsic satisfaction, satisfaction with the work one is doing, and extrinsic satisfaction, satisfaction with the conditions of the work environment. But Holland's theory only places emphasis on the intrinsic job satisfaction. Moreover, Holland's methods of measuring fit have been questioned as having failed to provide valid longitudinal data to support Person–Environmental fit (P-E fit) outcome-based results (Edwards, 1991). Hesketh and Gardner (1993) conducted the research and found no direct relationship influence in the Person–Environment fit. Hesketh also concludes this criticism of Holland's model in that it does not explain an individual's personality, which has a direct effect on job satisfaction. Holland's model fails to explain the additional unique personality traits which belong to the individual. Hesketh explains more that some personality types such as extroverts tend to be happier in several occupational environments. Lent and Savickas (1994) concluded that there are many factors which influence people's fit into their environment.

On the other hand, Prediger (1996) reported that there is enough evidence to support the hexagon as reality based. He conducted a research, and the data has been relied on in the analysis of data, things and people work-task dimensions. Support for this conclusion would include research conducted which involved the job analysis for 12,000 occupations and of interest inventory data for 1,000 career groups and 100,000

individuals. He recommended that the summary of 30 years of hexagon-based research by Holland is a mirror of reality.

> 'The key characteristic of the Hexagon model is the RIASEC order and the implied distance or relationship among the types. If these attributes did not hold most of the time, the research about the types would not support the expected similarities and differences…. The definition of consistency also depends on the hexagon model, so long as consistent. As it stands, consistency is clearly related to direction of choice.' (Holland, 1997, pp. 159–160)

Prediger concluded that Holland's hexagon is a mirror of reality.

On the one hand, differentiation of gender also raises interesting issues. Proyer and Hausler (2007) studied the differences between gender and they found that men often score higher on Realistic interests and women score higher on Social and Artistic interests. Hansen et al. (1993, cited Proyer & Hausler, 2007) said Holland's theory is more relevant to men more than women and they conclude that men and women may have the different views on Holland' personality dimension or focus on the different attribution of Holland's themes. From this issue, Holland has manipulated the booklet of inventory and answer sheet to two profile forms for male and female.

However, Holland believed that there are some reasons for career changes, such as, viewing or experiencing new vocational roles, new or changes of certain job expectations, specialty training which may limit the individual's vocational options, an occupational choice based on incomplete information, and lack of study of both personal and settings (Holland, Davis, & Cooley, 1975).

Holland's $(1985)_{(a)}$ theory was designed to explain career-related behaviour. Much research has been done on this theory such as Oliver and Waehler (2005) who examined the validity of Holland's 6 types of themes when applied to the diversity of nations. They found that the construct validity of Holland's typology had some support. The construct validity of Holland's typology with a Native Hawaiian sample which they defined as a variety of nation and culture mix together that was supported. Furthermore, Larson et al. (2007) determined whether the six personality traits and self-efficacy of Holland's theory which are used in America can be used in Asia or not. They found that the confidence across the RIASEC would significantly discriminate among the majors and career aspirations in Taiwanese college students.

On the other hand, Furnham (2001) criticised Holland's theory that even though people appear to have a free choice to choose their job, some limitations still restrict their choice, for example, the economic state of a region, history and geography.

Although they have full appropriate skills and traits, they cannot get that job. Others are limited by demographic factors like sex, age, social class, physiology, height, eyesight, and education. Moreover, Arnold (2004) analyzed Holland's theory. He found that there are three main weak points associations between congruence and outcome measures which are 1) Holland's measures of people and environments partially neglect some importance construct. 2) Environments have not been conceptualized or measured entirely appropriately. And 3) the data used in the analyzing of congruence indices are insufficiently precise or comprehensive. He suggested that Holland's theory needs to be developed further.

Holland's theory has been subject to criticism as described. However, whether it is entirely valid or not is not so important to this study because it was used purely as a guide to determine the choice of programmes. The intention was simply to strengthen the chance of determining differences between programmes if they existed. I chose seven programmes that are related to Holland's six career personalities as follows. The relevant career personality is given in brackets.

Marketing (enterprising)

Accounting (conventional)

Engineering (realistic)

Chemistry (investigative)

Visual art (artistic)

Elementary education (social 1)

Psychology (social 2)

3.2 Conceptual framework

As seen in the introduction and literature review, learning in Thailand has for a long time sought to improve pedagogy through different approaches. The government has endeavoured to encourage students to go to school and support the facilities as much as they can, for example, kindergarten is free of charge, primary school is compulsory but free, high school is not compulsory but free of charge, and if students would like to study in the university but they have no money, the government will give

them a loan with very low interest which they can pay back when they have worked after graduation.

The critical point facing the education system in Thailand is that universities cannot provide the places for all students who need it. Most high school students would like to go to university but the university cannot provide places for all of them. Therefore, the entrance system or ADMISSIONS or the method used to select high school students to come into university has considerable importance. Last two years, 2009, Thai government has set up a new regulation which requires students to test their aptitude and the score is used as one factor when considering offering a place. National Institute of Educational Testing Service (Public Organization) is set up for organizing the test. GAT (General Aptitude Test) and PAT (Professional Aptitude Test) are the most well-known and give high school students considerable anxiety. Reasoning skills and problem solving ability became two main factors of the test separated from perceptual ability, calculation skills, reading skills, and so on. Any skills or ability that is needed depends on what programme the students would like to get a place in and its level also depends on each university setting up their own criteria. The percentage of GAT and PAT is different between universities. (The National Institute of Educational Testing Service: NIETS, 2011)

Each study programme is assumed to need more or less different abilities and different skills. PAT has been separated into seven sets (Kasikornthai bank, 2011).

1. PAT 1 measures mathematics potential. The content would be examined such as: algebra, probability and statistics, conversion, geometry, trigonometry, calculus, and so on. And the test aims to examine perceptual ability, calculation skills, quantitative reasoning, and math reading skills.
2. PAT 2 measures science potential. The content would be examined such as: biology, chemistry, physics, earth sciences, environment, ICT. And the test aims to examine perceptual ability, sciences reading ability, science problem solving ability, and so on.
3. PAT 3 measures engineering potential. The content would be examined such as: engineering mathematics, engineering sciences, life sciences, IT. The test aims to examine engineering aptitude, multidimensional perceptual ability, calculation skills, engineering reading ability, and engineering problem solving ability.

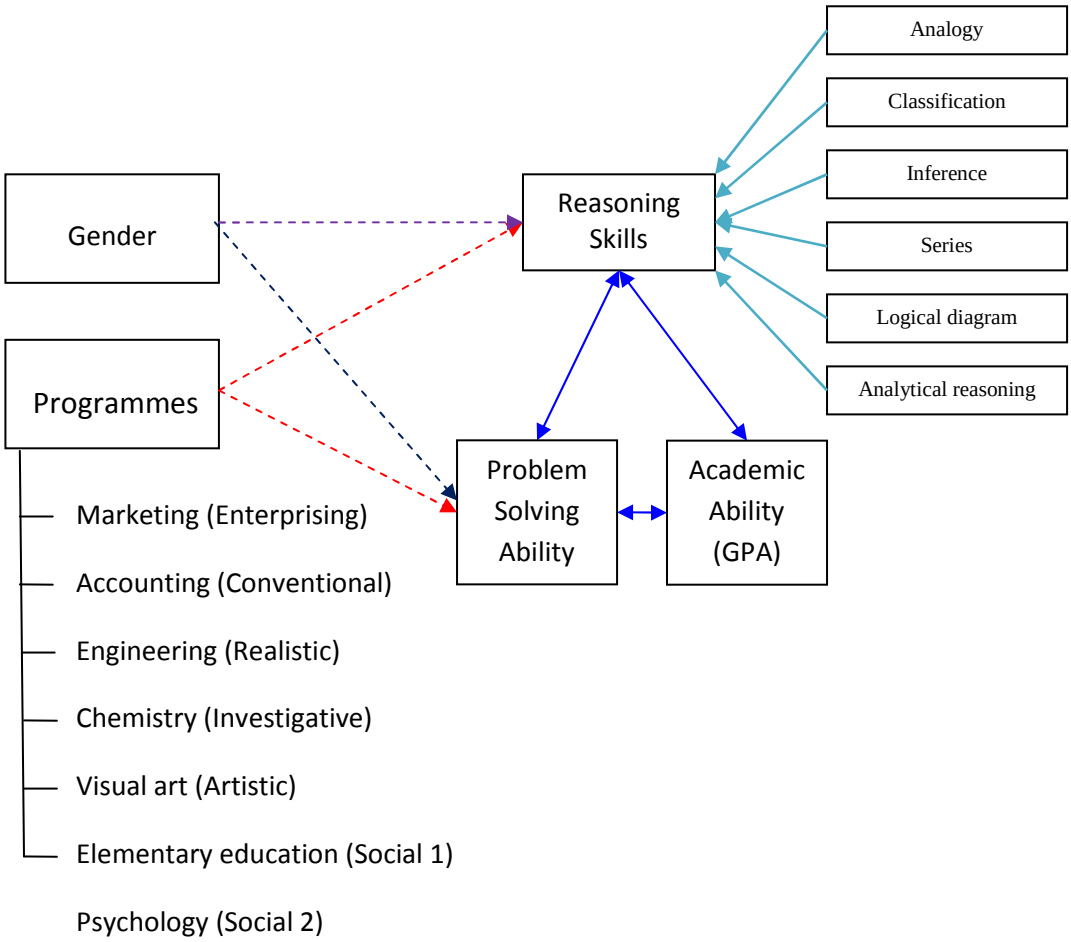
4. PAT 4 measures architectural potential. The content would be examined such as: architectural math and sciences, and so on. The test aims to examine space relations, multidimensional perceptual ability, and architectural problem solving ability.
5. PAT 5 measures educational potential. The content would be examined such as: the knowledge of Thai language, science, social science, anthropology, hygiene, art, environment, and so on. The test aims to examine pedagogy, reading skills, general knowledge of education in Thailand, solving problem ability related to students, co-worker, and school administrator.
6. PAT 6 measures art potential. The content would be examined such as: art science (visual art, music, dancing art), and general knowledge about art. The test aims to examine creative thinking and so on.
7. PAT 7 measures foreign language potential**.** The content would be examined such as: grammar, vocabulary culture, pronunciation functions. The test aims to examine paraphrasing, summarizing applying concepts and principles, problem solving skills, critical thinking skills, questioning skills, analytical skills.

Testing ability in a general way to suit all programmes of all universities seems to be very challenging. Fortunately, John Holland (1966) concluded his career choice theory into six different type of personality (detailed earlier in this chapter). And it is possible to collect the data from six programmes following Holland's theory.

Reasoning skills may influence problem solving ability. English (1998) suggested that children need to be made aware of the importance of the validation process, in all of their problem-solving activities. And the issue of how to improve learning still remains the key priority. Reasoning skills may influence academic ability too.

Therefore, this research was conducted by testing reasoning skills and problem solving ability, including academic ability (GPA) from students in six different programmes; marketing, accounting, engineering, chemistry, visual art, and elementary education, and another programme, psychology, which grouped with elementary education using Holland's theory at one University.

Figure 3.2 Show the conceptual framework



3.3 Design of research methods

There are many ways to conduct research. Likewise in educational research, there are some methods which are preferable for particular purposes such as naturalistic and demographic research, historical research, correlation research, longitudinal research, action research, quasi-experiments and single case research. To gather data, observation, interviews, accounts, role-playing, questionnaires, test and personal constructs are all useful.

Educational research often uses questionnaires and tests; however, questionnaires and tests are quite different. The questionnaire has an aim to seek opinions honestly, meanwhile the test usually asks questions but wants to determine something other than opinions, for example, IQ test, or psychological test.

Among many psychological tests, the reasoning skills test has been widely adopted. Newton and Bristoll (2010) conducted abstract reasoning tests with diagrams,

symbols and shapes instead of words and numbers. They suggested that the diagrams, symbols, and shapes do not involve ability in language and number which most reasoning tests usually require and may affect the test outcome. Hughes and Courteney (2010) have built both verbal reasoning test series and non-verbal reasoning test series for pupils' age between 7 years 3 months and 14 years 3 months. They explained that the tests help to assess pupils' future potential in that a pupil may acquire new concepts in a wide range of subjects including math, science and design and technology. Meanwhile, as introduced in chapter 2, Jittachaun (1992) has constructed a reasoning test in three formats; picture, language, and picture and language, with each test composed of the same questions and the same six factors; analogy, classification, inference, series, logical diagram, and analytical reasoning. The picture's reliability was .5694 and its validity was .4883. Meanwhile, the language's reliability was .7109 and its validity was .6218. Mixed picture and language's reliability was .7225 and its validity was .5507. All reliability and validity were significantly at the level of .01. Therefore, this study has adopted Jittachaun's reasoning test to test final year students' reasoning skills. The 30 reasoning items test and 5 problem solving ability items test, included respondents' demographic information, gender and GPA, which were also collected at the beginning of the test. The test did not ask any more demographic information, in order that the respondents would not be affected by anything.

The second part of this study focused on interviewing respondents. Respondents were randomly chosen and their interviews were recorded for data analysis purpose. All respondents were informed of the recording. Questions asked in the interviews were all semi-structured and they were all related to their opinion on how they viewed learning, reasoning, and problem solving ability. This study uses semi-structured interview to elicit students' explanations to their response answered in the test. Such semi-structured interview approach is known as *interview guide approach*. The topic and issues to be covered are specified in advance, in outline form; the interviewer decides the sequence and working of questions in the course of the interview.

3.4 Sampling

The sample in this study comprised a total of 333 final year students for the survey and 14 students for the interview, from seven programmes in one university. They are selected by purpose, following John Holland's career personality theory. The numbers shows on table 3.2 are separated by gender and programme.

Table 3.2 Number of participants

Programmes	Gender		Total
	Female	Male	
Marketing	27	24	51
Accounting	67	14	81
Engineering	31	19	50
Chemistry	44	5	49
Visual art	17	15	32
Elementary education	25	14	39
Psychology	23	8	31
Total	234	99	333

The total Sample size was 333 participants. It corresponded with the sample size used in Structural Equation Modelling (SEM) which relies on tests that are sensitive to sample size as well as to the magnitude of differences in covariance matrices. In the literature, sample sizes commonly run 200 - 400 for models with 10 - 15 indicators. One survey of 72 SEM studies found the median sample size was 198 (Garson, 2010). Loehlin (1992) recommended at least 100 cases, preferably 200. Hoyle (1995) confirmed a sample size of at least 100 - 200. Schumacker and Lomax (2004) examined the literature and found sample sizes of 250 - 500 to be used in most articles. A sample of 150 is considered too small unless the covariance coefficients are relatively large. With over ten variables, sample size under 200 generally means parameter estimates are unstable and significance tests lack power.

3.5 Research instruments

In this study, two sorts of data were collected by two different methods of collection. A test was employed to collect quantitative data of students' reasoning skills, problem solving ability, GPA, and gender. After the data collection, the results can generate a general picture of students' reasoning skills, problem solving ability and academic ability. The researcher found that something is interesting such as some students who have a very high GPA could not solve the problems in the test very well. Therefore, the use of student interviews allowed the researcher to investigate in greater depth significant points arising from the test results. Conducting semi-structured interviews also served the purpose of complementing and further explaining the answers

to the research questions which found unclear result in the tests, of which some needed further explanation and elaboration. Interviewing with students is therefore a complementary research tool to capture a complete picture of reasoning skills, ability to learn, and problem solving ability.

3.5.1 Test

The test administered in this study consists of 35 of 5 multiple choice items which is 5 items per subtest; 5 analogy item test (item 1-5), 5 classification item test (item 6-10), 5 inference item test (item 12-16), 5 series item test (item 18-22), 5 logical diagram item test (item 24-28), 5 analytical reasoning item test (item 30-34), and 5 problem solving ability item test (item 11, 17, 23, 29, and 35) (See appendix A). The reason the problem solving ability items were placed between the others was to encourage participants to answer those questions, if they were left at the end, from a pilot study it was found that they tended to ignore these questions, otherwise the time had finished. The 35 items test given to students was in Thai language, to avoid language barrier and communication breakdown.

Administering tests for validation

Kline (1983, p.9) said ‘a psychological test must be reliable, valid and discriminating’. He suggested that reliability could be tested and reported through various means: split-half reliability, the alpha coefficient, KR20, the factor analytic method, Hoyt’s analysis of variance method or the simple technique such as test-retest. Meanwhile, face validity, concurrent validity, predictive validity, and construct validity, are concepts used to describe and report validity. On the other hand, delta is used to calculate an index of discriminability. All of these elements are important in test construction.

To guarantee the quality of the test, Saiyot and Saiyot (2000) and Sangprateeptong (2010) explained how to check the quality of the test focusing both on items and the overall test. The item difficulty, discrimination of items, and the efficiency of distracters are the property of each item. In addition to those item qualities, validity and reliability are used for the whole test.

Validity means an ability of an instrument to measure the thing (construct) that the tester wants to measure, or to test the right thing. As mentioned above, according to Saiyot and Saiyot, and Sangprateeptong, there are four kinds of validity; content validity, construct validity, concurrent validity, and predictive validity. On the one

hand, reliability means an ability of an instrument which can measure and receive the same result. They have suggested test-retest, parallel test, and internal consistency; such as spilt half, KR20, KR21, and alpha coefficient, to report reliability. However, internal consistency estimates of reliability, Weir (2005) argued that 'these may be equally well regarded as evidence of validity'.

There are some discussions of validity. Messick (1995) said validity is an overall evaluative judgment of the accuracy of interpretations and actions on the fundamental test scores or the other modes of assessment, supported by the degree of empirical evidence and theoretical rationales. He placed an emphasis on construct validity; construct validity was based on an integration of any evidence which was grounded on the interpretation or meaning of the test scores including content and criterion-related evidence. However, several years before, Messick (1975) suggested that even though construct validity generally plays an important role, it is less important in educational measurement practice. He explained that construct validity is not usually required for educational tests because they are considered to be valid on content validity. Hambleton and Novick (1973, cited Messick, 1975) claimed that all criterion-referenced tests must have content validity.

To summarise, overall, there are two major properties of the test as a whole that most researchers recognise. The first is reliability and the second is validity.

The procedure for building the test took place in Thailand. Jittacheun's research has reported the difficulty of item, and discrimination of item for each item analysing, and content validity, and reliability for the whole test. He has started with reviewing literatures, set up the purposes, selected the pattern of the test, built the test, gave them to three experts to consider the content validity, first tried out, analysed the discrimination and difficulty of item, selected good quality items, second tried out, analysed the discrimination and difficulty of item again, selected good quality items, third tried out, analysed the whole test quality, reliability by correlating his test with the analogy reasoning standard test from Srinakarinwirot University, and finally created the Norms for his test (Jittachuan, 1992). The test's construction for this research followed the usual process in Thailand.

The difficulty of item and discrimination of item

The item difficulty and discrimination were calculated from the formula below after a pilot study was conducted.

'Item difficulty' or 'P value'

$$P = \frac{Ph + Pl}{2n}$$

'Discrimination value' or 'r value'

$$r = \frac{Ph - Pl}{n}$$

When Ph = number of the right answers within the high group.

Pl = number of the right answers within the low group.

n = number of students in each group.

The total scores from the highest to the lowest were sorted and then used 27% from the highest score and 27% from the lowest score to select the high group (Ph) and the low group (Pl), therefore, there were 11 students per group. A satisfactory score is for the P value to be between .2 and .8, and r value must be .2 and above. In this case, the researcher selected 34 items from them with 5 items per one factor except 'series' which had only 4 acceptable items; 5 analogy items, 5 classification items, 5 inference items, 4 series items, 5 logical diagram items, 5 analytical reasoning items, and 5 problem solving items. However, researcher would like all factors to have the same weight, the same item number, therefore, created one new item for series factor giving to total of 35 (See result on appendix B).

Reliability

The reasoning skills test was adopted from Jittachuen's test which has conducted for the final year primary school students in Thailand. The reliability was .7109. However, the test was adapted to be harder for the final year university students, and to

prevent less concentration and carelessness when the participants have answered the test for a long time and they may be tired and not be able to concentrate on the later test. Therefore, the test was conducted in one set by inserting the five items of problem solving ability test between the thirty items of reasoning skills test. For the student sample of 333, the reliability of the test, Cronbach's Alpha, was .633. The formula for Cronbach's alpha is as follows:

$$\hat{\alpha} = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} p_i(1-p_i)}{\hat{\sigma}_X^2}\right).$$

k is the number of items on the exam; p_i, referred to as the item difficulty, is the proportion of examinees that answered item i correctly; and $\hat{\sigma}_X^2$ is the sample variance for the total score (Wells & Wollack, 2003).

Content validity

Messick (1995) said the test content is relevant to the proposed test use which is judged by the experts. Content validity in this research was judged by four experts in the academic evaluation centre, Sukhothai Thammathirat Open University, Thailand. They considered and rated for the content validity, Index of item objective congruence (IOC). Any item which had content validity value less than 75% was deleted (Detail on appendix C).

Construct validity

To find out the construct validity, factor analysis (FA) needs to be analysed to prove that all factors were the same as the theory or the referenced factors. This research has followed Jittachuan's concept. He (Jittachuan, 1992) recommended 6 factors of reasoning skills. In order to confirm this structural model, structural equation modelling (SEM) was employed to assess. In addition, Standardized Regression Weights, Unstandardized Regression Weights, and Squared Multiple Correlations (R^2), of each observed variable were also assessed.

Confirmatory Factor Analysis (CFA) was conducted to estimate the quality of the structural reliabilities and designated factor loading by testing the model fit between

the proposed measurement models and the collected data. Table 3.3 presents the results of CFA with the fit indices, which are recommended (Hair et al., 2006).

Table 3.3 Show fit indices from CFA and fit guidelines

Fit index	Attribute of fit index	Good Fit Guidelines	Measurement Model's Output
χ^2	Absolute fit	Non-significant	.073
CFI	Incremental fit	>.90	.931
RMSEA	Badness-of-fit	<.08	.047

First, the chi-square statistic for testing the null hypothesis that the model is correct, ($\chi^2_{(9)} = 15.726$, p = .073) was not statistically significant.

Second, the CFI (Comparative Fit Index) (.931) indicated how much the variance-covariance in the original model is predicted by the reproduced matrix. The index greater than .90 indicated a good fit.

Finally, the index of RMSEA (Root Mean Square Error of Approximation) less than .08 indicates a good fit; it corresponds with the value of .047 which is a good fit.

The result shown the model fit well with the data to confirm the six factors from Jittacheun's recommendation. However, the assessment of CFA should not be dependent only on a fit index, but should be investigated with several methods to address several attributes from various fit indices by at least one index of each attribute (Kline, 2005). Based on the fit indices, the hypothesized model of CFA was accepted as a reasonable fit to the data, by satisfying the criteria of three indices (RMSEA, χ^2, and CFI).

Table 3.4, below, presents the results in which all factor loadings were statistically significant at p <.05 and the measures included in the study can be considered as reasonable results that confirmed the existence of reflection of the underlying latent variable, reasoning skills.

Table 3.4 Maximum likelihood estimates for CFA

Parameter			Unstandardized Regression Weights	Standardized Regression Weights	Squared Multiple Correlations	P
Classification	<---	Reasoning Skills	.204	.229	.052	.002
Inference	<---	Reasoning Skills	.439	.361	.131	.000
Series	<---	Reasoning Skills	.630	.512	.262	.000
Logical diagram	<---	Reasoning Skills	.616	.531	.282	.000
Analytical reasoning	<---	Reasoning Skills	.681	.471	.222	.000
Analogy	<---	Reasoning Skills	.182	.180	.032	.014

In addition, squared multiple correlation (R^2) represented how much variation in an observed variable was explained by the latent variable, which was calculated by squaring the standardized factor loading. For instance, reasoning skills accounted for 22.2% of the variation in analytical reasoning, 26.2% of the variation of series, and 28.2% of the variation of logical diagram.

The purpose of SEM was to determine whether the theoretical relationships specific at the conceptualization stage are supported by the collected data. This hypothesized confirmatory model yielded an overall χ^2 value of 15.726, with 9 degrees of freedom. The significant model in the chi-square ($p = .073$) statistic can be considered as representative of a good fit. The others indices, RMSEA (.047), and CFI (.931) suggested that it was relatively well-fitting. It was therefore concluded that all relationships between variables were well accounted for by the model. **Construct validity was reported**.

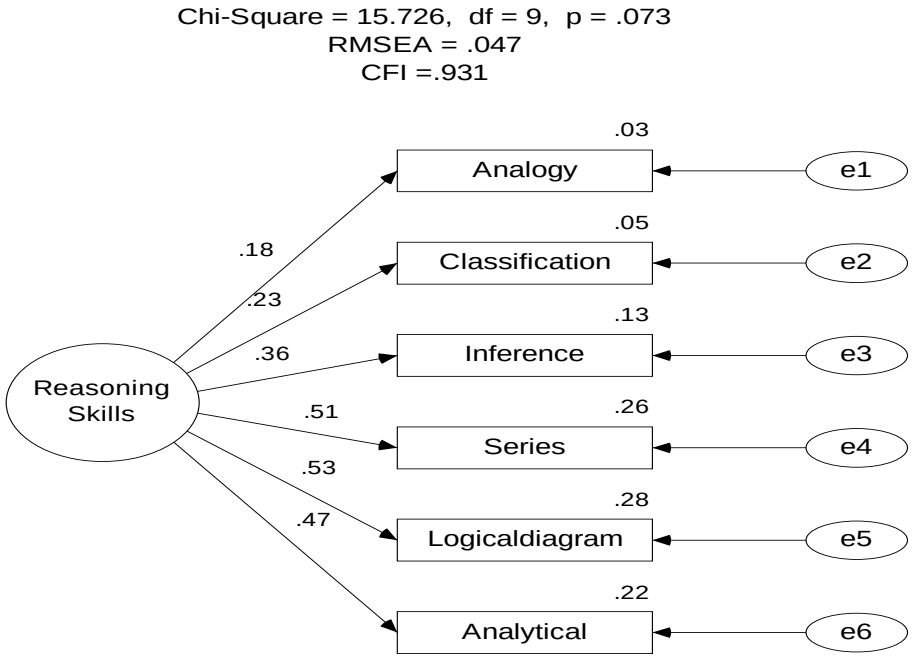


Figure 3.3 Hypothesized confirmatory model

Discriminant Validity

Campbell and Fiske (1959) suggested from their cumulative past 50 years' experience, there are two major validations on which a researcher or test developer should seek clarification, convergent validity, and divergent validity or discriminant validity. They explained that if the correlations between different tests are high, then that test has a convergent validity; however, if the correlations between different tests are low, that test has discriminant validity. The test used in this research needed discriminant validity because the sub-tests are independent objective and they were intended to measure different aspects; analogy, classification, inference, series, logical diagram, and reasoning analysis. The result reported quite low relationship between each sub-tests (See table 3.5 below). Therefore this test has discriminant validity.

Table 3.5 Correlations between each reasoning skills sub-tests

		Analogy	Classifica-tion	Inference	Series	Logical diagram	Analytical
Analogy	Pearson Correlation	1	-.027	.046	.058	.111*	.146**
	Sig. (2-tailed)		.626	.404	.294	.043	.008
	N	333	333	333	333	333	333
Classification	Pearson Correlation	-.027	1	.145**	.129*	.095	.104
	Sig. (2-tailed)	.626		.008	.019	.082	.057
	N	333	333	333	333	333	333
Inference	Pearson Correlation	.046	.145**	1	.098	.243**	.189**
	Sig. (2-tailed)	.404	.008		.075	.000	.001
	N	333	333	333	333	333	333
Series	Pearson Correlation	.058	.129*	.098	1	.297**	.277**
	Sig. (2-tailed)	.294	.019	.075		.000	.000
	N	333	333	333	333	333	333
Logical diagram	Pearson Correlation	.111*	.095	.243**	.297**	1	.192**
	Sig. (2-tailed)	.043	.082	.000	.000		.000
	N	333	333	333	333	333	333
Analyti-cal	Pearson Correlation	.146**	.104	.189**	.277**	.192**	1
	Sig. (2-tailed)	.008	.057	.001	.000	.000	
	N	333	333	333	333	333	333

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Overall, this research has reported the analysing of item property, item difficulty, item discrimination, and the validation of the test, reliability, content validity, construct validity, and discriminant validity.

Scoring

Respondents who chose the right answer got one, otherwise, they got zero. Therefore:

1. The 30 reasoning items test has total 30 scores which compose of analogy test 5 scores, classification test 5 scores, inference test 5 scores, series test 5 scores, logical diagram test 5 scores, and analytical reasoning test 5 scores.

2. The problem solving ability test has total 5 scores.
3. GPA is grade point average in system of 4. The truth is that different programmes studied different subjects and used different standards to evaluate the GPA. Therefore, the score from each programme must be adjusted to true score (T-score) before analyzing.

$$\text{T-score} = \left(\frac{x-\bar{x}}{S.D.}\right)10 + 50$$

4. Gender, researcher has encoded 0 for female and 1 for male.
5. Programmes were coded by numbers and detail is in the label.

3.5.2 Interview

Semi-structured interviews were conducted after statistical results were preliminarily analysed. As there were areas presented in the statistical results which needed to be explained by the participants who have taken the test, the interviews were conducted with those participants to fill in the gaps in areas which needed to be explained.

Fourteen students were randomly interviewed in total. The researcher had asked two participants per programme to be interviewees after the data were preliminarily analysed. They were interviewed by phone because it was convenient for everyone.

The questions were phased to explain the research questions in a way which was more individual and open for them to talk about; however, if they ignored some issues, the researcher encouraged them to think about them. Questions asked in interview were mainly the core questions (See below).

Guiding interview questions

- What skills are useful for studying?
- Any skills use for problem solving?
- Is there a correlation between reasoning skills and problem solving ability? How much?
- Is there a correlation between academic ability and reasoning skills? How much?
- What is the characteristic of a person who can use reasoning very well?
- How do reasonable people use their reason?

- Do you think a person can solve problems without reasoning - which skills can he/she use?
- How much reasoning skills do people in your career need?
- Do you think other students who are studying in different programmes need the same level of reasoning as you or not? Who needs more?
- After you have graduated and go to work, and if you have got some problems, how you can solve the problems?
- If you have a dilemma, what will you do?
- What were the reasons that you have selected this programme?

3.6 Procedures

Starting with 67 items that the researcher adapted for collecting the data then they were brought to four experts from Academic Evaluation Centre, Sukhothai Thammathirat Open University, Thailand, to consider and rate for the content validity; index of item objective congruence (IOC).

First of all, they were given the written objective of the test that researcher would like to test, for example, **Analogical Objective**: *the 10 following items aim to find out the similarity in some respects between things that are otherwise dissimilar. It is a form of logical inference or an instance of it, based on the assumption that if two things are known to be alike in some respects, then they must be alike in others.*

Then they were shown the test and the objective and asked to criticize and rate the congruence of each item to the objective above on the opinion rating column, for example:

Item	**Instruction**: Please select a choice which has correlation the same with the given word before	Agree	Unsure	Dis-agree
1	duck : egg ⇒ butterfly : ? chrysalis caterpillar worm parasite tussock moth (a.) b. c. d. e.			

Later, IOC value was calculated by giving 1 for the ‘agree’, giving 0 for ‘unsure’ and giving -1 for the ‘disagree’ opinion. They were added and divided by 4. The item

which had a result less than 0.5 (75%) was defined as irrelevant and not able to evaluate the objective, and was cut off.

$$\text{IOC value} = \frac{\sum x}{n} = \frac{x1 + x2 + x3 + x4}{4}$$

So, 6 items were cut off. Moreover, the researcher developed some of the test items under the experts' advice.

After cutting off and developing some items then they became a 61 items test. A pilot study was carried out before the final test was set. Firstly, 40 random students took part in the preliminary test and completed 39 set of the test. The item difficulty and discrimination were calculated (See the result on appendix B). Eventually, the 35 items test was conducted. The pilot study showed that approximately 60 minutes to finish 61 items. Therefore, researcher set up the 35 items test with a time limited of 40 minutes for answering.

Seven programmes of final year students which Holland personality's theory recommended were the sample groups: Marketing, Accounting, Mechanical engineering, Chemistry, Visual art, Elementary education, and another; Psychology.

3.7 Data analysis

Data collected from the feedback on the test was analysed by using computer programme, SPSS, and AMOS. Several statistical applications and analysis were employed in this study.

Firstly, descriptive statistics were used to illustrate the characteristics of students in seven programmes.

Secondly, Structural Equation Modelling was employed to examine factor loading of six sub-reasoning test; to confirm reasoning skills factor and also structural validity: Analogy, Classification, Inference, Series, logical diagrams, and Analytical reasoning.

Thirdly, Two-ways Multivariate Analysis of Variance (Two-way MANOVA) was employed to examine the differences of reasoning skills score, and problem solving ability score between six main programmes and gender. And t-test was used to analyse the differences of the similar programmes (elementary education and psychology).

Fourthly, Structural Equation Modelling was employed to test the model fit of reasoning skills, problem solving ability and academic ability, and to examine factor loadings between them.

Lastly, interviewing by telephone was conducted with an attempt to understand students' responses better in the context of reasoning skills, problem solving ability and academic ability. The qualitative data obtained were transcribed from the respondents' first language (Thai) into English for codification. The data were analysed manually by categorizing the answers based on specific markers. The markers were on par with the heading set for this study. That is, for example, Ac1 for the first Accounting student, Ac2 for the second Accounting student, A1 for the first visual Art student, and so on. These classification enabled the researcher to effectively further investigate the statistical results and transcripts could also be used to supplement the answers found from the statistical data.

3.8 Ethical issues

There are a number of measures adopted to try to protect better the rights of the participants of the study. Firstly, the principle of voluntary participation was adopted to ensure that participants were not being forced into taking part in research. The researcher explained to the participants that their answers would not affect anything in relation to them and they could stop anytime they want. It is not compulsory. Meanwhile, permission to conduct the study was sought from the university ethics committee.

Ethical standards also require that researcher does not put participants into the situation where they might be at risk of harm as a result of their participation. Harm can be defined as both physical and psychological. There are two measures that were applied in order to help protect the privacy of the prospective participants.

Firstly, the researcher guaranteed the participants confidentiality; they were assured that identifying information would not be made available to anyone who is not directly involved in the study.

Secondly, the principle of anonymity would be applied to make sure that the participants would remain anonymous throughout the study. The participants were not required to fill in their names. When interviewing, participants were not asked the names.

3.9 Operational Definitions

Reasoning skills mean the thinking skills which focus on six factors; analogy, classification, inference, series, logical diagram, and analytical reasoning.

Problem solving ability means ability to solve the problems which researcher has adopted by the logical puzzle, real world problem, and mathematical puzzle.

Academic ability means ability to study in the university of the final year students which was evaluated by the Grade Point Average system, (GPA).

Programme means the academic programme or subject they were following. The choice of programme for the study was based on Holland's theory of vocational choice which defined six career personalities by the work environment: Realistic personality, Investigative personality, Artistic personality, Social personality, Enterprising personality, and Conventional personality.

Ac1 means the first accounting student.

Ac2 means the second accounting student.

A1 means the first visual art student.

A2 means the second visual art student.

E1 means the first education student.

E2 means the second education student.

En1 means the first engineering student.

En2 means the second engineering student.

M1 means the first marketing student.

M2 means the second marketing student.

C1 means the first chemist student.

C2 means the second chemist student.

P1 means the first psychological student.

P2 means the second psychological student.

Chapter 4

Analysis of results

This chapter will present the statistical results of all the research questions set and hypotheses for this study and analyse and present the interviewees' responses with regard to their reasoning skills, problem solving ability, and academic ability.

The presentation of this chapter follows the research questions and hypotheses of this research. To find out the relationship and comparison between reasoning skills, academic ability, problem solving ability, personality, and gender, the following findings are the results of investigation.

To answer research question 1: do the students from the similar programme have the same reasoning skills and problem solving ability? (Hypotheses 1 and 2). The researcher ran t-test between two groups, elementary educational students and psychological students who were generalized to belong in the same category according to Holland's theory.

Hypothesis 1: Students from similar programmes (career personality) have the same level of reasoning skills.

Table 4.1 Descriptive statistics of reasoning skills between elementary educational students and psychological students

	Programme	N	Mean	Std. Deviation	t
Reasoning Skills	Elementary education (Social Personality 1)	39	17.4615	3.46293	-.998
	Psychology (Social Personality 2)	31	18.2258	2.78938	

p = .322

There are 39 elementary educational students and 31 psychological students whose reasoning skills scores means were 17.462 and 18.226, and standard deviations were 3.463 and 2.789 respectively. The t value was -.998 and the Sig. value was .322. Therefore the reasoning skills scores between elementary educational students and psychological students did not show statistically significant difference.

Hypothesis 2: Students from similar programmes (career personalities) have the same level of problem solving ability.

Table 4.2 Descriptive statistics of problem solving ability between elementary educational students and psychological students

	Programme	N	Mean	Std. Deviation	t
Problem Solving ability	Elementary education (social personality 1)	39	2.3333	1.38285	.239
	Psychology (Social personality 2)	31	2.2581	1.21017	

p = .812

There are 39 elementary educational students and 31 psychological students whose problem solving ability means were 2.333 and 2.258, and standard deviations were 1.383 and 1.210 respectively. The t value was .239 and the Sig. value was .812. Therefore the problem solving ability between elementary educational students and psychological students was not statistically significant difference.

To answer research question 2: do the students' reasoning skills and problem solving ability from different programmes differ, and research question 3: do the students' reasoning skills and problem solving ability from different genders differ, (the hypotheses 3, 4, and 5, 6) it is better to run MANOVA instead of conducting a series of ANOVA and t-test separately. Pallant (2007) said that to avoid inflated Type I error, if there are more than one dependent variable running MANOVA is needed. Therefore, the researcher ran two-way MANOVA first.

Analysing MANOVA

Before going directly to the results, it would be better to know the procedure of MANOVA analysis. The proceeding with the main MANOVA analysis, its assumptions need to be analysed first. The major assumptions of MANOVA are:

- Independence: Observations should be statistically independent.
- Random sampling: Data should be randomly sampled from the population of interest and measured at an interval level.
- Multivariate normality: Dependent variables have multivariate normality with groups.

- Homogeneity of covariance matrices: the correlation between any two dependent variables is the same in all groups.

From those assumptions, data were analysed to check the assumptions.

Table 4.3 The descriptive statistics of reasoning skills and problem solving ability separated by gender and programme

	Gender	Programme	Mean	Std. Deviation	N
Reasoning _Skills	Female	Engineering	16.7742	3.29353	31
		Chemistry	16.0000	3.72921	44
		Visual art	11.5294	2.21127	17
		Elementary education + psychology	17.3958	3.06483	48
		Marketing	13.0741	3.30415	27
		Accounting	17.9701	2.93862	67
		Total	16.2906	3.71763	234
	Male	Engineering	17.0000	3.72678	19
		Chemistry	19.2000	1.09545	5
		Visual art	11.7333	2.43389	15
		Elementary education + psychology	18.6818	3.32933	22
		Marketing	16.0417	3.38127	24
		Accounting	19.0000	3.16228	14
		Total	16.7374	3.96048	99
	Total	Engineering	16.8600	3.42863	50
		Chemistry	16.3265	3.67643	49
		Visual art	11.6250	2.28247	32
		Elementary education + psychology	17.8000	3.18329	70
		Marketing	14.4706	3.62962	51
		Accounting	18.1481	2.98375	81
		Total	16.4234	3.79096	333
Problem_ Solving_ Ability	Female	Engineering	2.7097	1.37097	31
		Chemistry	2.7500	1.38304	44
		Visual art	1.6471	.86177	17
		Elementary education + psychology	2.3333	1.22619	48
		Marketing	1.8519	1.09908	27
		Accounting	2.6716	1.25997	67
		Total	2.4530	1.29041	234
	Male	Engineering	3.0526	1.12909	19
		Chemistry	2.6000	1.14018	5
		Visual art	1.3333	1.04654	15
		Elementary education + psychology	2.2273	1.47783	22
		Marketing	2.6250	1.27901	24
		Accounting	2.4286	.93761	14
		Total	2.3939	1.30006	99

Total	Engineering	2.8400	1.28349	50
	Chemistry	2.7347	1.35055	49
	Visual art	1.5000	.95038	32
	Elementary education + psychology	2.3000	1.30050	70
	Marketing	2.2157	1.23796	51
	Accounting	2.6296	1.20876	81
	Total	2.4354	1.29161	333

The descriptive statistics explained the number of participants in each cell, separated by gender and programme. Meanwhile mean and standard deviation are also displayed in this table. The total is 333 participants which are composed of female 234 and male 99; the smallest number is 5 participants in male and following the chemistry programme. The highest number is female and following the accounting programme, 67. The highest reasoning skills were from the accounting programme, 18.1481, and the lowest reasoning skills was from the visual art programme (artistic personality), 11.6250. The highest problem solving ability was from the engineering programme (realistic personality), 2.8400, and the lowest was from the visual art programme, 1.5000.

Table 4.4 Box's Test of Equality of Covariance Matrices[a]

Box's M	33.271
F	.957
df1	33
df2	11559.783
Sig.	.538

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Gender + Programme + Gender * Programme

Box's Test of Equality of Covariance Matrices told whether the data violates the assumption of homogeneity of varience-covarience matrices. If the Sig. value is larger than .05, the data have not violated the assumption. In other words, these data Sig. = .538 which is greater than .05, hence, the covariance matrices are equal and the assumption is tenable.

Table 4.5 Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Reasoning_Skills	1.169	11	321	.308
Problem_Solving_Ability	1.297	11	321	.225

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Gender + Programme + Gender * Programme

Levene's Test of Equality of Error Variances tests the null hypothesis that the error variance of the dependent variable is equal across groups. If the Sig. value is less than .05, this means the variances between groups are not equal which has violated the assumption of equality of variance of that variable. The table above show that those two variable, reasoning skills and problem solving ability, has not violated the assumption of MANOVA.

Table 4.6 Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Reasoning_Skills	1510.907[a]	11	137.355	13.523	.000	.317
	Problem_Solving_Ability	58.094[b]	11	5.281	3.420	.000	.105
Intercept	Reasoning_Skills	56876.208	1	56876.208	5599.717	.000	.946
	Problem_Solving_Ability	1199.414	1	1199.414	776.598	.000	.708
Gender	Reasoning_Skills	119.564	1	119.564	11.772	.001	.035
	Problem_Solving_Ability	.138	1	.138	.090	.765	.000
Programme	Reasoning_Skills	1297.662	5	259.532	25.552	.000	.285
	Problem_Solving_Ability	41.503	5	8.301	5.375	.000	.077
Gender * Programme	Reasoning_Skills	75.164	5	15.033	1.480	.196	.023
	Problem_Solving_Ability	10.101	5	2.020	1.308	.260	.020
Error	Reasoning_Skills	3260.390	321	10.157			
	Problem_Solving_Ability	495.768	321	1.544			
Total	Reasoning_Skills	94591.000	333				
	Problem_Solving_Ability	2529.000	333				
Corrected Total	Reasoning_Skills	4771.297	332				
	Problem_Solving_Ability	553.862	332				

a. R Squared = .317 (Adjusted R Squared = .293)

b. R Squared = .105 (Adjusted R Squared = .074)

A test of Between-Subjects Effects is used for testing the differences between each group for example, male and female, and programme differences. Normally, the Sig. value less than .05 is considered that there is difference between groups; however, Tabachnick and Fidell (2007) recommended dividing the original alpha level, .05, with the number of dependent variable to prevent the familywise Type I error; the finding of significant result while there is not really significance. The Sig. value in the row of gender, programme, and gender*programme are considered. If the Sig. value is less than .025 (.05/2, the new alpha level), the differences between groups has occurred. Therefore, reasoning skills between male and female are different. And also, reasoning skills and problem solving ability between different programmes are differences which need to be tested further. Meanwhile, there were no interactions between gender and programme of both reasoning skills and problem solving ability, the Sig. value higher than .025. On the other hand, the problem solving ability of males and females was not a statistically significant difference, the Sig. value higher than .025.

Overall, a two-way between groups multivariate analysis of variance (two-way MANOVA) was performed to investigate the differences of variables. Two dependent variables were used: reasoning skills and problem solving ability. The independent variables were gender and academic programme. Preliminary assumption testing was conducted to check for normality, linearity, and homogeneity of variance-covariance matrices, with no violations reported.

There was a statistically significant difference between males and females on reasoning skills, $F_{(1, 321)} = 11.772$, $p = .001$, partial eta squared = .035. An inspection of the mean scores indicated that females reported slightly lower levels of reasoning skills (*Mean = 16.2906, SD = 3.71763*) than males. (*Mean = 16.7374, SD = 3.96048*) On the contrary, there was not a statistically significant difference between males and females on problem solving ability, $F_{(1, 321)} = .090$, $p = .765$, partial eta squared = .000.

The importance of the impact of gender on reasoning skills (*partial eta squared = .035*) are considered a ***small*** effect. Pallant (2007) explained how to interpret the strength of the different effect size statistics which proposed by Cohen (1988, p.22; cited Pallant, 2007, p. 208).

Table 4.7 Interpreting the strength of the different effect size statistics

Size	Eta squared (% of variance explained)
Small	.01 or 1%
Medium	.06 or 6%
Large	.138 or 13.8%

Meanwhile there was a statistically significant difference between programme on reasoning skills, $F_{(5, 321)} = 25.552$, $p = .000$, partial eta squared = .285 (28.5%) and there was a statistically significant difference between programme on problem solving ability, $F_{(5, 321)} = 5.375$, $p = .000$, partial eta squared = .077 (7.7%). It is clear from the table 4.9 that programme has a ***large*** effect on the reasoning skills, and ***medium*** effect on problem solving ability. However, which pair of programmes has different reasoning skills? Which pair of programmes has different problem solving ability? Post Hoc tests were used in order to answer these questions.

Hypothesis 3: Students from different programmes have different level of reasoning skills.

There was a statistically significant difference of programmes on reasoning skills; therefore, Multiple Comparisons must be used. To run Multiple Comparisons, *post hoc* tests were employed to the test. There are many comparisons method to select; however, Field (2005) recommended that if the sample sizes are very different, like this research, use *Hochberg's GT2*.

Table 4.8 Multiple comparisons; *Hochberg's GT2*, of reasoning skills on different programmes

(I) Programme	(J) Programme	Mean Difference (I-J)	Std. Error	Sig.
Engineering	Chemistry	.533	.654	1.000
	Visual art	5.235*	.736	.000
	Elementary education + psychology	-.940	.602	.847
	Marketing	2.389*	.647	.004
	Accounting	-1.288	.585	.347
Chemistry	Engineering	-.533	.654	1.000
	Visual art	4.702*	.739	.000
	Elementary education + psychology	-1.473	.606	.208
	Marketing	1.856	.650	.067
	Accounting	-1.822*	.588	.031
Visual art	Engineering	-5.235*	.736	.000
	Chemistry	-4.702*	.739	.000
	Elementary education + psychology	-6.175*	.694	.000
	Marketing	-2.846*	.733	.002
	Accounting	-6.523*	.679	.000
Elementary education + psychology	Engineering	.940	.602	.847
	Chemistry	1.473	.606	.208
	Visual art	6.175*	.694	.000
	Marketing	3.329*	.599	.000
	Accounting	-.348	.531	1.000
Marketing	Engineering	-2.389*	.647	.004
	Chemistry	-1.856	.650	.067
	Visual art	2.846*	.733	.002
	Elementary education + psychology	-3.329*	.599	.000
	Accounting	-3.678*	.581	.000
Accounting	Engineering	1.288	.585	.347
	Chemistry	1.822*	.588	.031
	Visual art	6.523*	.679	.000
	Elementary education + psychology	.348	.531	1.000
	Marketing	3.678*	.581	.000

*$p < .05$

The cohort from the visual art programme has reasoning skills totally different from the others. The marketing group of students (enterprising personality) has a statistically significant difference from others except those taking chemistry. The others have some differences. The differences can be concluded as table 4.9 (below). The highest reasoning skills were accounting, 18.148, and the lowest reasoning skills was visual art, 11.625.

Table 4.9 The reasoning skills' differences between programmes

Programme	Accounting $\bar{x}$ = 18.148	Education+ psychology $\bar{x}$ = 17.800	Engineering $\bar{x}$ = 16.860	Chemistry $\bar{x}$ = 16.326	Marketing $\bar{x}$ = 14.471	Visual art $\bar{x}$ = 11.625
Accounting $\bar{x}$ = 18.148		.348	1.288	1.822*	3.678*	6.523*
Education+ psychology $\bar{x}$ = 17.800	-.348		.940	1.473	3.329*	6.175*
Engineering $\bar{x}$ = 16.860	-1.288	-.940		.533	2.389*	5.235*
Chemistry $\bar{x}$ = 16.326	-1.822*	-1.473	-.533		1.856	4.702*
Marketing $\bar{x}$ = 14.471	-3.678*	-3.329*	-2.389*	-1.856		2.846*
Visual art $\bar{x}$ = 11.625	-6.523*	-6.175*	-5.235*	-4.702*	-2.846*	

*$p < .05$

Hypothesis 4: Different personalities have different level of problem solving ability.

There was a statistically significant difference of personality on problem solving ability; therefore, Multiple Comparisons, *Hochberg's GT2*, were employed to analyse the data.

Table 4.10 Multiple comparisons; *Hochberg's GT2*, of problem solving ability on different programme

(I) Programme	(J) Programme	Mean Difference (I-J)	Std. Error	Sig.
Engineering	Chemistry	.105	.250	1.000
	Visual art	1.340*	.282	.000
	Elementary education + psychology	.540	.230	.256
	Marketing	.624	.248	.167
	Accounting	.210	.224	.998
Chemistry	Engineering	-.105	.250	1.000
	Visual art	1.235*	.283	.000
	Elementary education + psychology	.435	.232	.610
	Marketing	.519	.249	.436
	Accounting	.105	.225	1.000
Visual art	Engineering	-1.340*	.282	.000
	Chemistry	-1.235*	.283	.000
	Elementary education + psychology	-.800*	.266	.041
	Marketing	-.716	.281	.155
	Accounting	-1.130*	.260	.000
Elementary education + psychology	Engineering	-.540	.230	.256
	Chemistry	-.435	.232	.610
	Visual art	.800*	.266	.041
	Marketing	.084	.229	1.000
	Accounting	-.330	.203	.808
Marketing	Engineering	-.624	.248	.167
	Chemistry	-.519	.249	.436
	Visual art	.716	.281	.155
	Elementary education + psychology	-.084	.229	1.000
	Accounting	-.414	.222	.623
Accounting	Engineering	-.210	.224	.998
	Chemistry	-.105	.225	1.000
	Visual art	1.130*	.260	.000
	Elementary education + psychology	.330	.203	.808
	Marketing	.414	.222	.623

*$p < .05$

Only the visual art students have problem solving ability different from the others except the marketing students that has not differed. Apart from visual art students (artistic personality), others were not different from each other. The differences can be concluded as table 4.11 (below). The highest problem solving ability was found in the engineering students (realistic personality), 2.840, and the lowest problem solving ability was in visual art (artistic personality), 1.500.

Table 4.11 The problem solving ability's differences between programmes

Programme	Engineering $\bar{x}$ = 2.840	Chemistry $\bar{x}$ = 2.735	Accounting $\bar{x}$ = 2.630	Education+ psychology $\bar{x}$ = 2.300	Marketing $\bar{x}$ = 2.216	Visual art $\bar{x}$ = 1.500
Engineering $\bar{x}$ = 2.840		.105	.210	.540	.624	1.340*
Chemistry $\bar{x}$ = 2.735	-.105		.105	.435	.519	1.235*
Accounting $\bar{x}$ = 2.630	-.210	-.105		.330	.414	1.130*
Education+ psychology $\bar{x}$ = 2.300	-.540	-.435	-.330		.084	.800*
Marketing $\bar{x}$ = 2.216	-.624	-.519	-.414	-.084		.716
Visual art $\bar{x}$ = 1.500	-1.340*	-1.235*	-1.130*	-.800*	-.716	

*$p < .05$

Hypothesis 5: Male and female have different reasoning skills.

Table 4.12 Group Statistics of reasoning skills between genders

	Gender	N	Mean	Std. Deviation	Std. Error Mean	$F_{(1,321)}$
Reasoning_Skills	Female	234	16.29	3.718	.243	11.772**
	Male	99	16.74	3.960	.398	

**$p < .01$

There were 234 female and 99 male to be participants. From the total score of 30, the mean of females was equal to 16.29 and standard deviation was equal to 3.718. Meanwhile the mean of males was equal to 16.74 and standard deviation was equal to 3.960. The table 4.6 also presented the comparison of reasoning skills between gender and the results confirm that males and females were different; $F_{(1, 321)} = 11.772$, $p < .01$.

Hypothesis 6: Male and female have different problem solving ability.

Table 4.13 Group Statistics of problem solving ability between genders

	Gender	N	Mean	Std. Deviation	Std. Error Mean	$F_{(1,321)}$
Problem_Solving_Ability	Female	234	2.45	1.290	.084	.090
	Male	99	2.39	1.300	.131	

p = .765

There were 234 females and 99 males to be participants. From the total score of 5, the mean of females was equal to 2.45 and standard deviation was equal to 1.290. Meanwhile the mean of males was equal to 2.39 and standard deviation was equal to 1.300. The table 4.6 also presented the comparison of problem solving ability between gender and the results confirm that males and females were **not** different; $F_{(1, 321)}$ = .090, p = .765.

To answer research question 4; do the reasoning skills, students' problem solving ability and academic ability influence each other, the hypotheses 7, 8, and 9, Structural Equation Modelling (SEM) were employed to assess the data. However, Structural Equation Modelling (SEM) needs to be understood in relation to the concept of analysing and its procedure before reading the results. Therefore, the steps to perform SEM are presented.

Steps to perform SEM analysis

1. Model specification

The first step is the model specification to form the picture of all variables that will be analysed. There are two kinds of model, structural model and measurement model, which a modeller should know. Except that it is a correlation between variables, and path, which the modeller can impose on his or her demand. The modeller does often specify a set of theoretically plausible models in order to assess whether the model proposed is the best of the set. The model which the modeller has designed for testing his or her hypothesis is called hypothesized model.

2. Assessment of the fit of the model and parameters

Secondly, the programme computer will determine the hypothesized model and the sample data. If the model fits well with the data, then the parameters can be considered. If the model fit does not fit well, the parameters cannot conclude. Some of the common used measures of fit are;

- Chi-Square (χ^2) is a function of the sample size and the difference between the observed covariance matrix and the model covariance matrix.
- Root Mean Square Error of Approximation (RMSEA)
- Comparative Fit Index (CFI)

3. Model modification

Thirdly, the model may need to be modified in order to improve the fit. AMOS provides modification indices which report the improvement in fit for those results by adding an additional path to the model. The modifications also make theoretical sense.

4. Interpretation

Lastly, the model is then interpreted and claims about the constructs are made based on the best fitting model. The result can be explained by supporting with careful research design or plausible theory.

To answer the fourth research question, SEM was employed to assess the model. The measurement model was set up by combining reasoning skills variable, problem solving ability variable, academic ability variable, and their indicators. The portion of the model that specifies how the observed variables depend on the unobserved, or latent, variables is sometimes called the **measurement model** (Arbuckle, 2007). The current model has three distinct measurement sub-models (See figure 4.1).

The researcher has brought reasoning skills with its indicators, problem solving ability, and academic ability with their indicators to form the hypothesized structural model. The model aims to find the subset of the dashed arrows that provides the answers for hypotheses 7, 8, and 9.

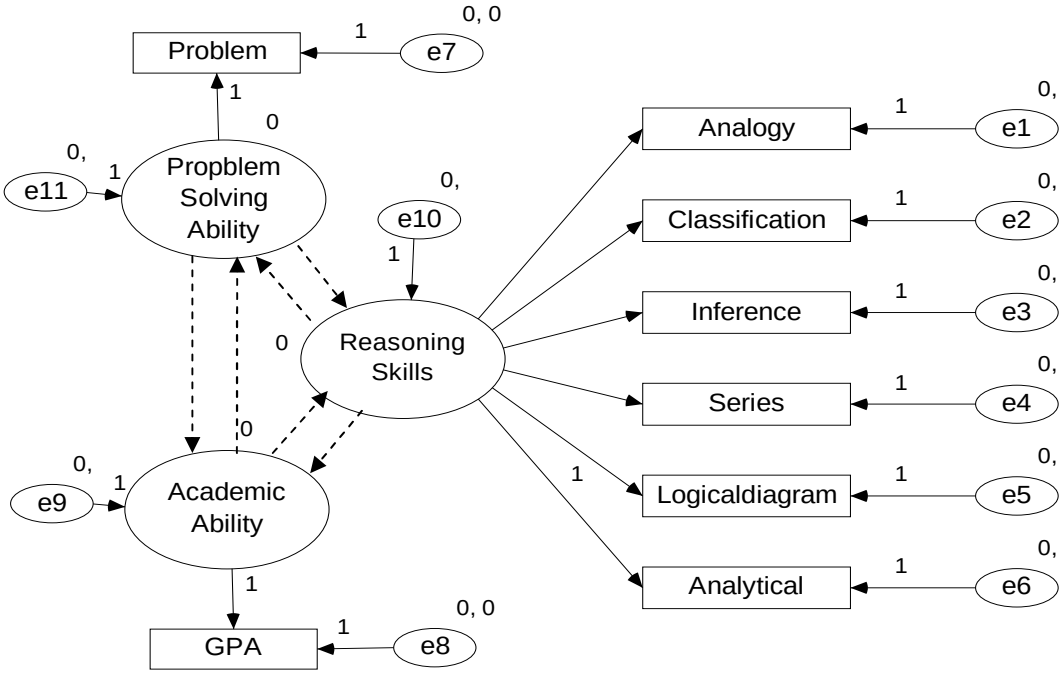


Figure 4.1 Hypothesized structural model of reasoning skills, problem solving ability, and academic ability

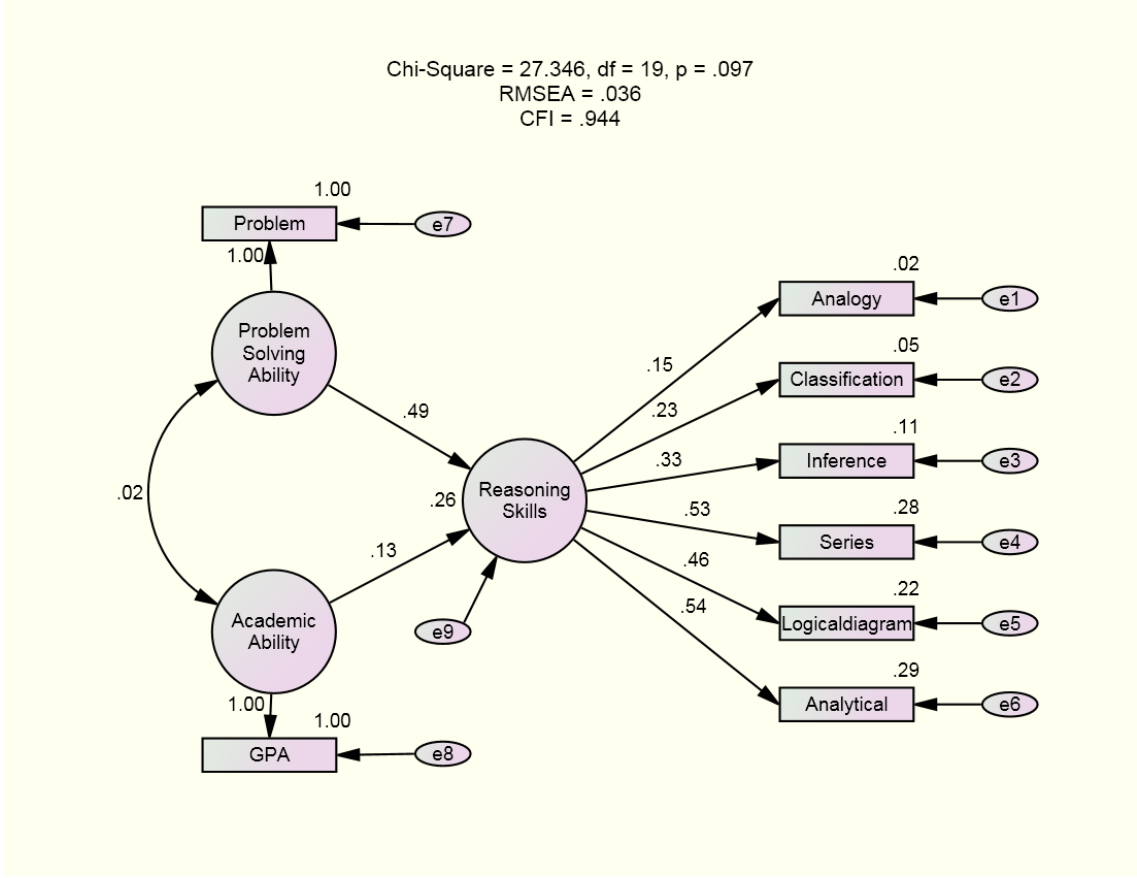


Figure 4.2 The first fitting model

The first model that SEM has provided was shown on the figure 4.2 which explained the influences of problem solving ability and academic ability on reasoning skills, and their factors. From the figure 4.2, the fit indices; $\chi^2_{(19)} = 27.346$, p = .097, RMSEA = .036, and CFI = .944, were considered a good fit. However, AMOS provided the ***modification indices*** for improving the fitting value.

On the one hand, the modification indices are the expected values that the chi-square would decrease by if such a parameter were to be included. A series of modifications was conducted to produce the most appropriate model by using modification indices produced in AMOS outputs. However, the misspecified error covariance may be representative of systematic measurement error derived from either the variables or the respondents (Aish & Joreskog, 1990).

However, not all modification indices can be adjusted; in order to decide which one was necessary, an additional review was employed. The information from the modification indices provided by AMOS outputs suggested some unreasonable relationships between error terms, which were not consistent with the study. Therefore, some suggestions were considered or ignored because modification indices identified by AMOS as belonging in a model are based on statistical criteria only. The inclusion of some covariance must be substantively meaningful for the study (Byrne, 2010). Overall, the researcher has adjusted two covariance between error 3 and error 5, and error 4 and error 5. The results were presented in figure 4.3.

Hypothesis 7: The reasoning skills were influenced by students' problem solving ability and academic ability.

The researcher, at this moment, concentrated on the structural model. The portion of the model that specifies how the latent variables are related to each other is sometimes called the **structural model** (Arbuckle, 2007). The seventh hypothesis focused on structural model of the influences of students' problem solving ability and academic ability on reasoning skills.

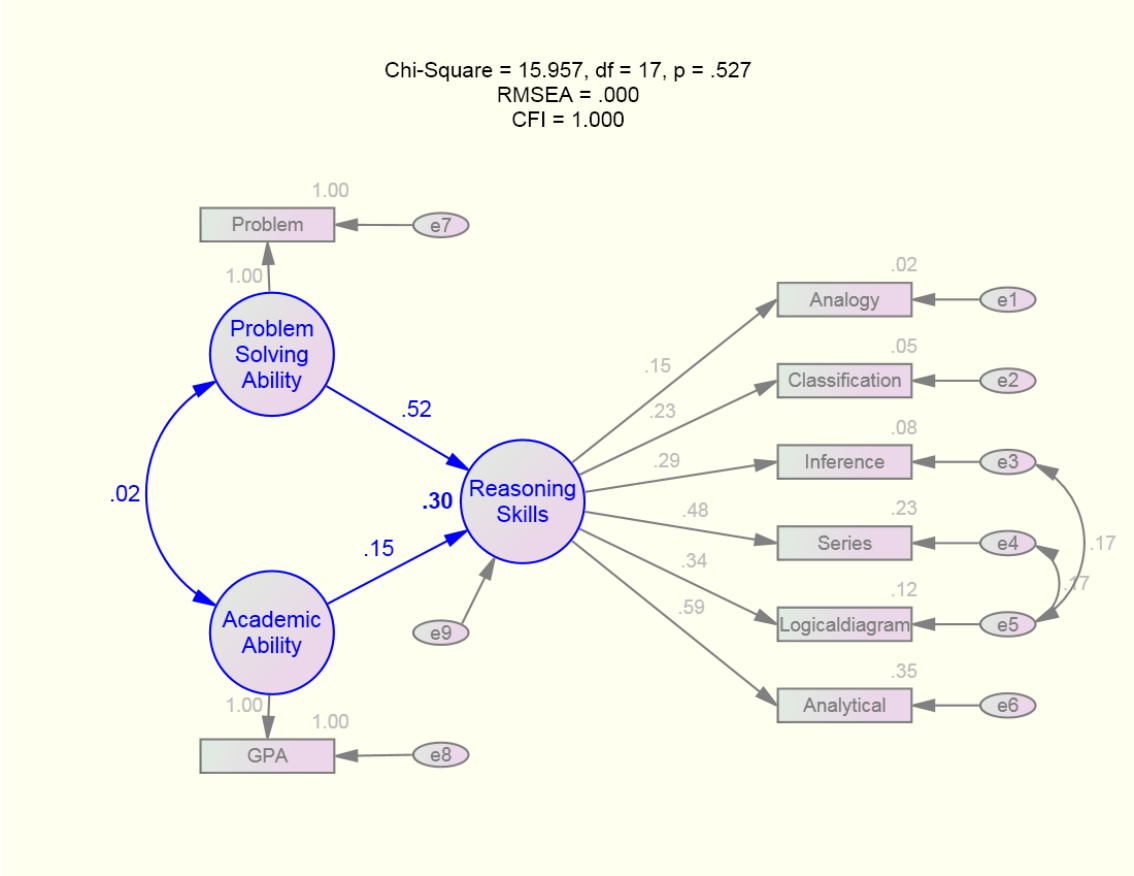


Figure 4.3 Structural model of reasoning skills were influenced by problem solving ability and academic ability

Figure 4.3, the model fitted very well, the fit indices $\chi^2_{(17)} = 15.957$, $p = .527$, CFI = 1.000, and RMSEA = .000. It supported the seventh hypothesis that the reasoning skills were influenced by problem solving ability and academic ability. And also the dimensions of regression weights were positively related from both problem solving ability and academic ability. Meanwhile, the correlation between problem solving ability and academic ability was very low (.02).

The model was a standardized estimation of reasoning skills that were influenced by problem solving ability and academic ability. The standardized regression weight which problem solving ability influenced on reasoning skills was .52 and the standardized regression weight which academic ability influenced on reasoning skills was .15. It was estimated that problem solving ability and academic ability, both, explained 30 percent of reasoning skills variance, the Squared Multiple Correlations (R^2) = .30 (Detail of analysing on appendix D).

Hypothesis 8: The students' problem solving ability was influenced by reasoning skills and academic ability.

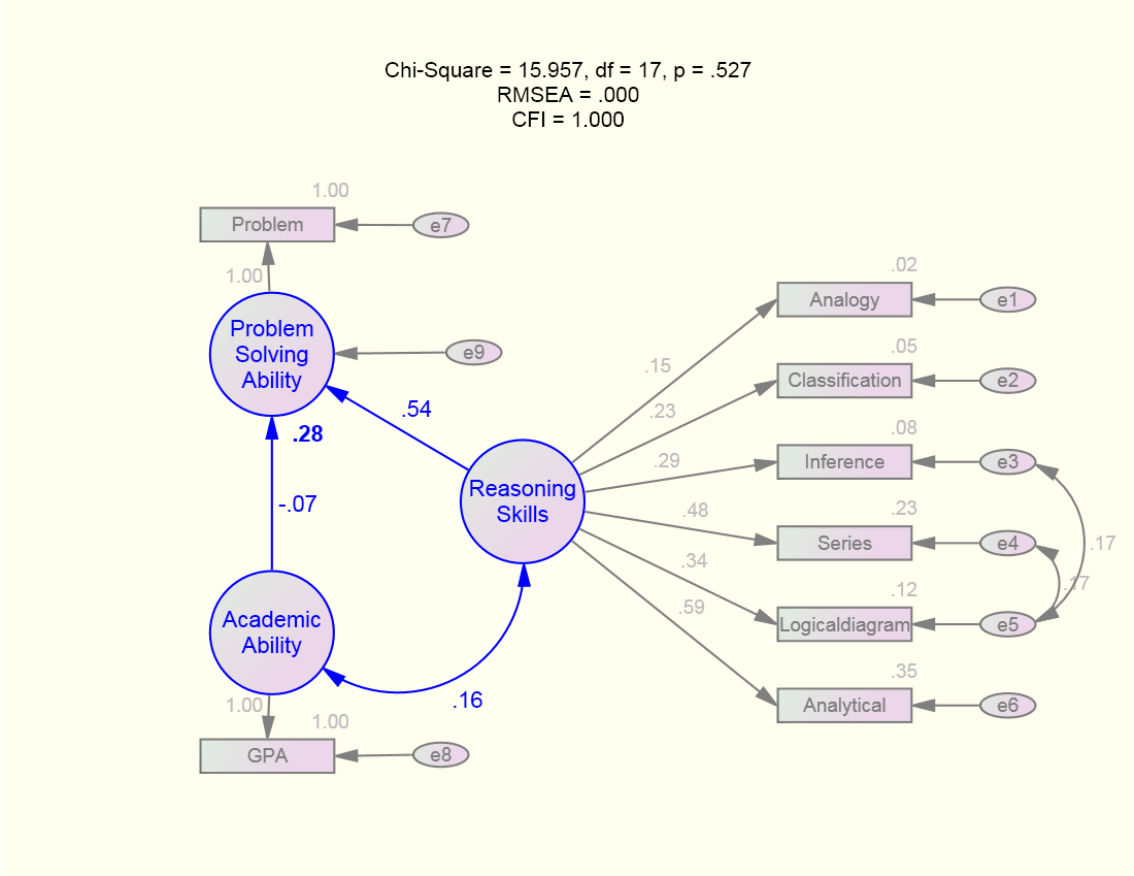


Figure 4.4 Structural model of problem solving ability was influenced by academic ability and reasoning skills

Figure 4.4 shows the model of a standardized estimation of problem solving ability was influenced by academic ability and reasoning skills, and fitted very well, the fit indices $\chi^2_{(17)} = 15.957$, $p = .527$, CFI = 1.000, and RMSEA = .000. It supported the eighth hypothesis that problem solving ability was influenced by reasoning skills and academic ability. The dimension of reasoning skills regression weight was positively related to problem solving ability (.54); however, regression weight of academic ability was negatively related to problem solving ability (-.07). It was estimated that problem solving ability variance was 28 percent explained by academic ability and reasoning skills, the Squared Multiple Correlations (R^2) = .28. Meanwhile, the correlation between reasoning skills and academic ability was low (.16) (Detail of analysing on appendix E).

Hypothesis 9: The academic ability was influenced by students' problem solving abilities and reasoning skills.

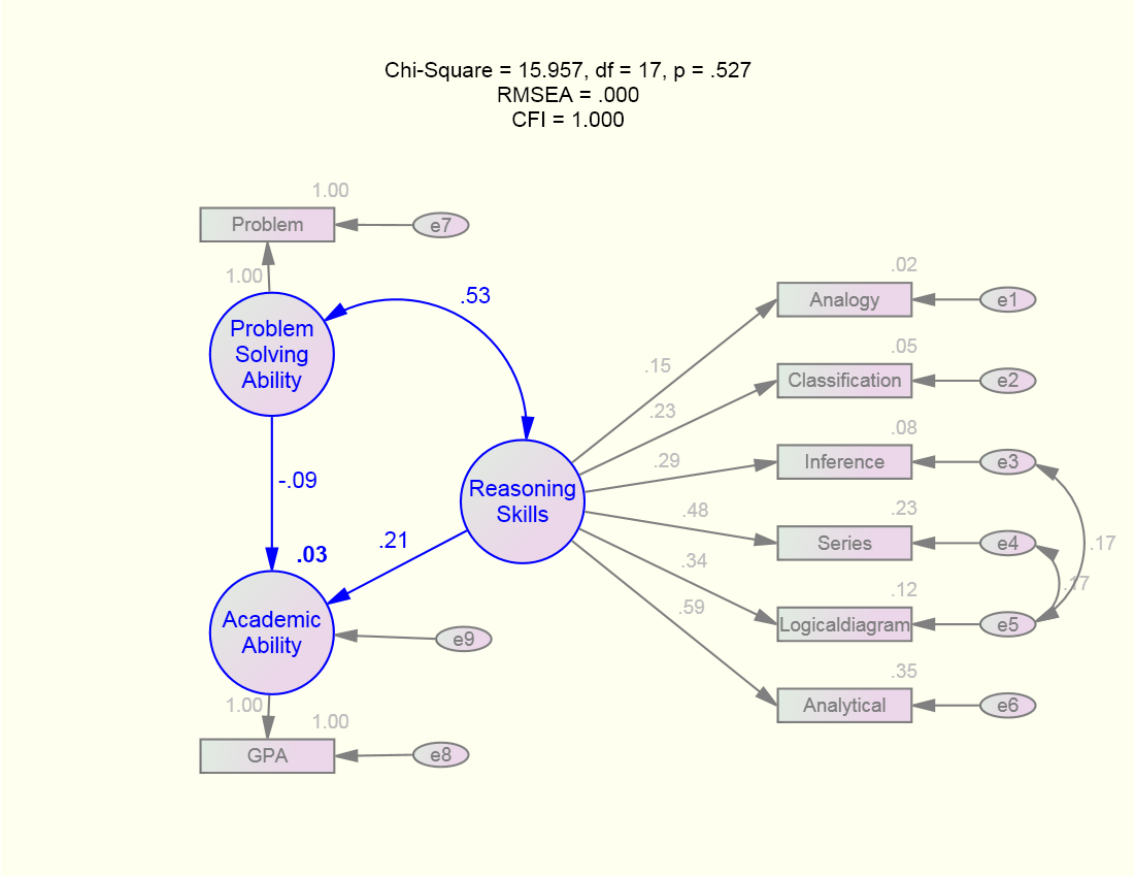


Figure 4.5 Structural model of academic ability was influenced by reasoning skills and problem solving ability

Figure 4.5 shows the model of a standardized estimation of academic ability was influenced by reasoning skills and problem solving ability, and fitted very well, the fit indices $\chi^2_{(17)}$ = 15.957, p = .527, CFI = 1.000, and RMSEA = .000. It supported the ninth hypothesis that academic ability was influenced by problem solving ability and reasoning skills. The dimension of reasoning skills regression weight was positively related to academic ability (.21); however, regression weight of problem solving ability was negatively related to academic ability (-.09). It was estimated that academic ability variance was 3 percent explained by problem solving ability and reasoning skills, the Squared Multiple Correlations (R^2) = .03. Meanwhile, the correlation between reasoning skills and problem solving ability was moderate (.53) (Detail of analysing on appendix F).

The influences and standardized regression weights between reasoning skills, problem solving ability, and academic ability can be summarized as figure 4.6 below.

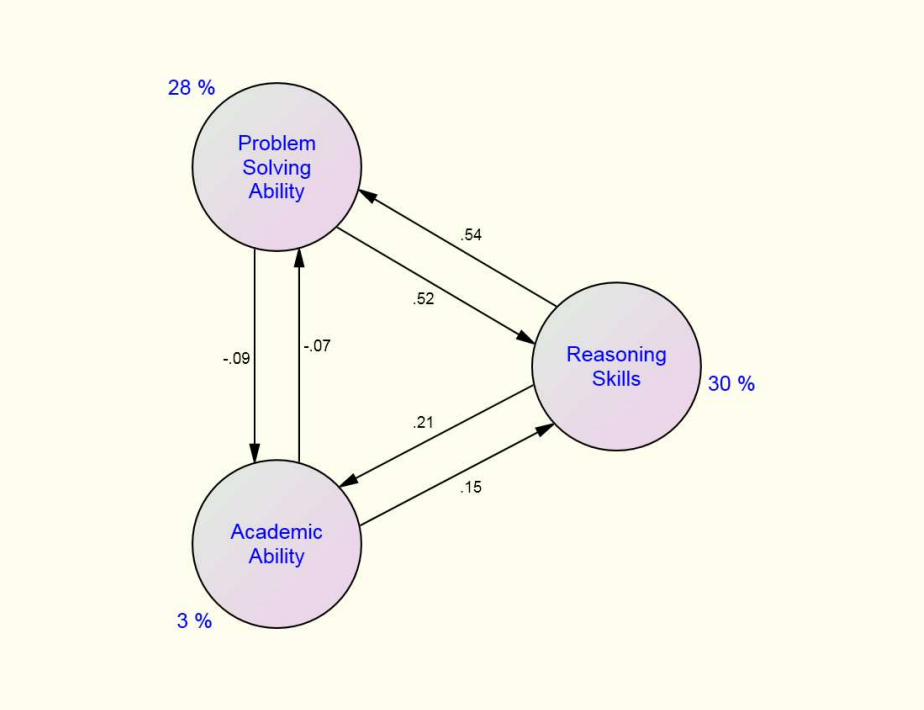


Figure 4.6 The influences and standardized regression weights between reasoning skills, problem solving ability, and academic ability

Nevertheless, some parameters on the figure 4.6 may not be familiar to some readers. The researcher would like to make it easier to understand by showing the percentage of correlation values between reasoning skills, problem solving ability, and academic ability instead of the standardized regression weights, on the figure 4.7 below.

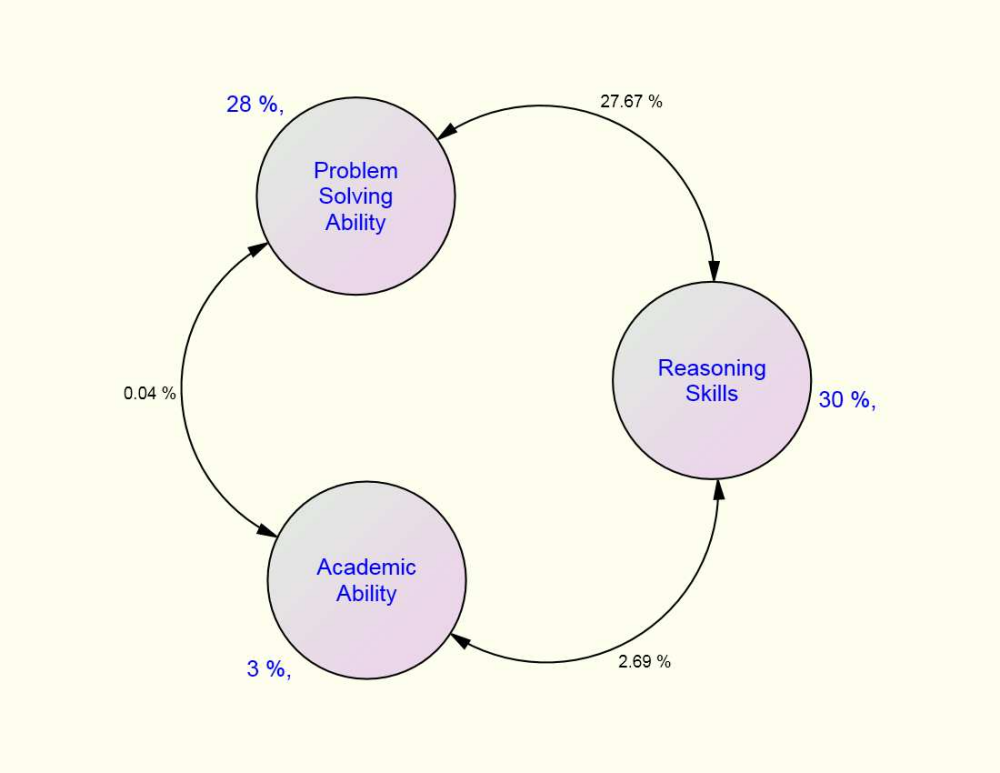


Figure 4.7 The influences and the percentage of correlation values between problem solving ability, academic ability, and reasoning skills

Figure 4.7 shows that the correlation between reasoning skills and problem solving ability was 27.67 percent, whereas the correlations between academic ability and reasoning skills, and academic ability and problem solving ability were very few, less than 3 percent. Because the relationship between academic ability and problem solving ability is very low, therefore, this result introduces the idea of how the direct and indirect effect of academic ability influences problem solving ability through reasoning skills if we consider that developing academic ability is the first and main thing we do to the students. The result is shown below.

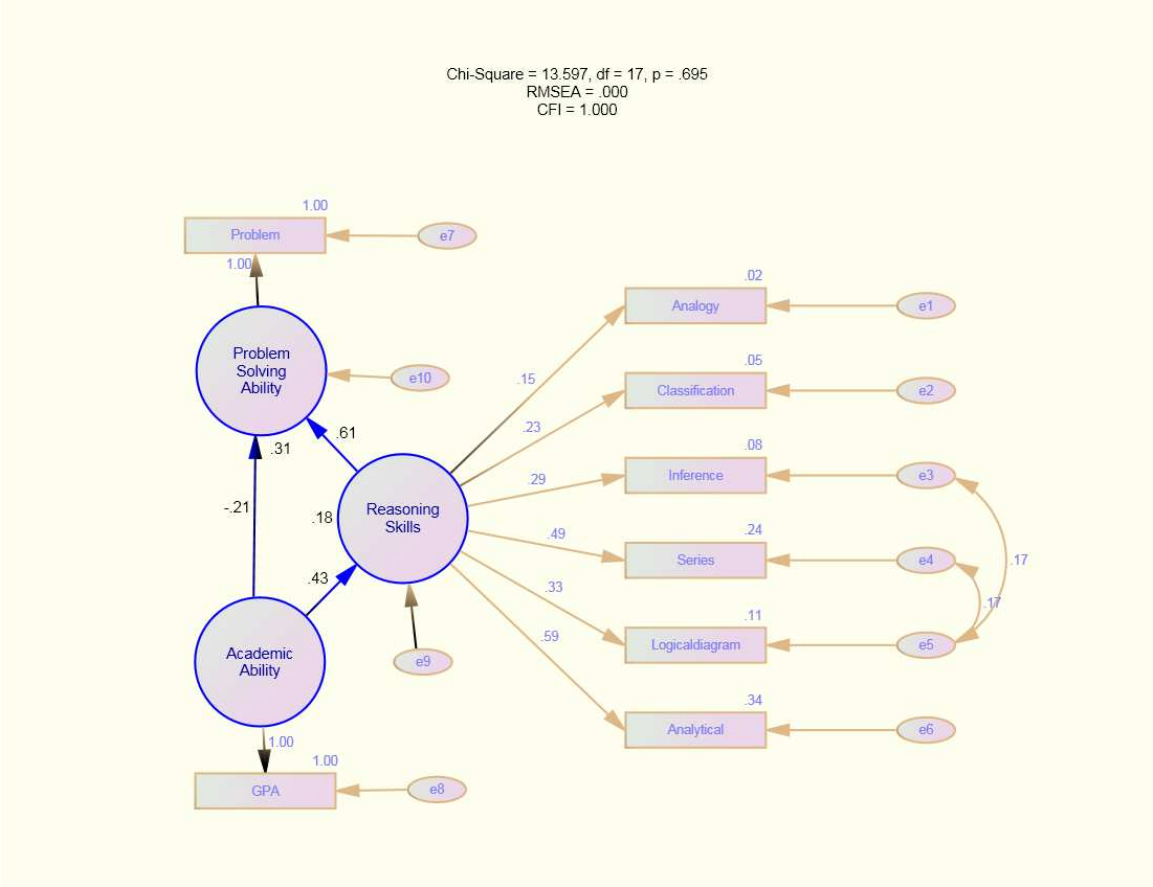


Figure 4.8 The influences from academic ability to reasoning skills and problem solving ability

Table 4.14 Standardized Direct Effects

	Academic_Ability	Reasoning_Skills
Reasoning_Skills	.426	.000
Problem_Solving_Ability	-.206	.614

And

Table 4.15 Standardized Indirect Effects

	Academic_Ability	Reasoning_Skills
Reasoning_Skills	.000	.000
Problem_Solving_Ability	.262	.000

Figure 4.8 and table 4.14 and table 4.15 present the direct and indirect effect from academic ability to problem solving ability which the negative direct effect (-.206) and positive indirect effect (.262) through the reasoning skills.

Overall, the quantitative results of this research can be concluded as follow;

1. The reasoning skills scores between similar programmes (with the same career personalities), elementary educational students and psychological students, did not show statistically significant difference.
2. The problem solving ability scores between similar programmes, elementary educational students and psychological students, did not show statistically significant difference.
3. The reasoning skills scores between male and female showed a statistically significant difference.
4. The problem solving ability scores between male and female did not show a statistically significant difference.
5. The reasoning skills scores between students from different programmes showed a statistically significant difference.
6. The problem solving ability scores between students from different programmes showed a statistically significant difference.
7. The reasoning skills were influenced by students' problem solving ability and academic ability by 30 percent.
8. The students' problem solving ability was influenced by reasoning skills and academic ability by 28 percent.
9. The academic ability was influenced by students' problem solving abilities and reasoning skills by 3 percent.

Chapter 5

Qualitative data

Introduction

In addition to the quantitative data, qualitative data, in the form of interviews, was collected from fourteen interviewees engaged in seven different studying programmes. Their opinions can be seen as providing supplementary data in the form of a bird's-eye view of their understanding of academic ability, reasoning skills and problem solving ability.

The headings for reporting the data derived from the key themes that were identified and can be summarized as follows;

1. Skills to learn
2. Skills to solve the problem
3. Reasoning skills with problem solving, and learning
4. Un/Reasonable people characteristics
5. The differences of reasoning skills between careers
6. Problem solving in the future
7. Reasons to select programme for studying

1. Skills to learn

It was interesting that the skills students identified as being closely involved with their general learning ability were varied such as, remembering, summarizing, analyzing, intention, carefulness, concentration, diligence, being interested, and thinking skills. However, the skills which they thought could help their studying better depended on their subjects as the second engineer students said;

'En2: It depends on the subjects, most of my studying is about calculation, so I need more thinking skills and some basic skills; however, I need to read the theory and apply to a practice.'

This idea was supported by analysing the answers from students studying different programmes. The same question was put by the researcher to all interviewees;

what skills can help improve your studying? The first art student answers were ‘drawing and moulding skills’ while the second said ‘creation, concentration, and work toleration’. These skills seemed particularly related to the person who is working on art or studying art. On the other hand, the first marketing student answers were ‘listening and speaking skills’. Although these could be seen as being more general, they seemed to be intended for the marketer who would like to use their listening and speaking skills to encourage customers to purchase some products. The accounting students focused on ‘remembering, summarizing, analysing, and carefulness’. These skills look suitable for the person who is working with numbers such as an accountant. This notice showed that the skills students thought can help their studying better usually related to their subjects. However, the most common general characteristics identified from fourteen students were diligence, concentration, intention, thinking skills, and being interested.

On the one hand, the second education student has explained the meaning of ‘being interested’ like this;

‘E2: …interested in the issue which is studying, so this can help studying better, for example, I am interested in math, I will read math, then I will become good in math. It seems like we usually say, we have an aptitude in this subject.’

This suggests that even when students referred to more general skills, they had their specific subject area or programme very much in mind.

He also explained more details that if someone was born with normal ability, they can increase their learning ability by taking more interest and applying self-study to the subjects.

‘E2: Somebody has a high IQ level, or clever, I think it is one part of studying; however, somebody who has not a high IQ level but can have a good GPA, I think it is because of their interest and self-study. Meanwhile the clever students take fewer times to understand the lesson.’

Overall, the skills which can increase the studying ability seem varied, and depended on the subject that students are learning; however, the core skills that interviewees recommended would be diligence, concentration, intention, thinking skills, and interesting.

2. Skills to solve the problem

The word ‘problem solving’ is familiar; however, how people solve the problem seems more interesting. The qualitative data shows that participants when approaching

problem solving intend to 1) find the causes of the problem, including considering the environment or context of the problem, 2) find the best method to solve the problem, sometimes by consulting the teachers or knowledgeable people, 3) solve the problem with reasoning, consciousness, self-experience by solving from one part to another part and slowly. Moreover, knowing one's own strong points and weak points can help you cope with the problem more efficiently.

'E1: Try to think about everything which may relate to the problem and then find the best way to solve the problem. The most, I consult friends, teachers, or supervisor, it depends on what kind of problem. If the problem is about studying, project, or activity, I will consult friends.'

The case of emergency problems was addressed. These were considered as important problems because sometimes a decision needs to be made in a very short time, for example, in the case of an accident. Therefore, the intelligence quotient was important but, interestingly, emotion quotient or emotional intelligence, self-awareness, empathy, and dealing sensitively with other people, and good relationships were recommended as being important also.

'E2: ... I think the important skills could be urgent problem solving skills because the urgent solving skills is necessary and very important, because we must think suddenly what we are going to do, because if we cannot think, we will miss the chance that we may get. The second skills, I think it is human-relationship; for example, the previous problem, dead car, if we have good human-relationship skills, we can beg someone for a lift. Not only high IQ, but high EQ too. It can help a lot, really.'

The different careers viewed the method to solve the problem from different angles. For example the marketer recommended good communication to solve problems.

'M1: They might be facing problem skills, experiences, and speaking, speak arranging.'

On the other hand, chemists recommended reasoning skills as being particularly important. This indicated that the career or the environment which they are associated with or their context of study seemed to affect the way they thought or made decisions.

'C1: It must have reasoning to solve the problem. If there is a problem but has no reasoning and just use emotion, the problem might not be solved. It wants the cooperation with the reasoning.'

In summary, skills identified to solve the problem may be reasoning skills, experience, consciousness, and human-relationship. However, more important than skills was the process to solve the problem which were 1) finding the causes of the problem, 2) searching the best way to solve the problem, and 3) solving by using reasoning skills, consciousness, or any skills which may relate to the problem solving.

3. Reasoning skills with problem solving, and learning ability

This section refers to the way in which the students saw the relationship between reasoning skills and both problem solving and learning ability. The reasoning skills were viewed as the factors that related to many abilities. Especially, they thought reasoning skills can help find the causes of the problem and make them clearer. These will make solving the problem more likely and more accurate.

'C2: It is necessary because we will know the real causes and we can solve at the root of the problem, not at the end of the problem.'

It seems reasoning skills related to everything; however, reasoning skills was not seen as being related to the learning by all students. Some opinions took the view that reasoning was not necessary for their learning.

'C1: Reasoning…learning…not sure. May be not related to each other. For example, learning is a course, except there are the questions why you answer like this, reasoning may relate to. Normally, learning does not relate to reasoning.'

'A1: I think they are related to each other; however, art may not need reasoning.'

And some viewed reasoning skills for answering the question while they are studying.

'C1: Yes, it is necessary; such as, every lesson must have their reason in themselves. We need to understand; for example, a question asks about why or what something was like that? We need the reason to answer that question.'

Overall, there are some reasons to say that reasoning skills related to problem solving; however, they were not sure that reasoning skills related to learning ability.

4. Un/Reasonable people characteristics

This section describes what the student saw as particular characteristics of people they saw as 'reasonable' or 'unreasonable'. Reasonable people were seen as reliable people, displaying qualities of solemnity, prudence and maturity. They were also seen as knowledgeable, optimistic, methodical and not easily discouraged. However, they were seen in two aspects. The first was someone who might be described as a faker or insincere and the second was someone who always presented the truth or was genuine.

'C1: There are two types. May I say directly? The first one is a faker, and the second is genuine.'

It is interesting that sometimes some people who did something that seemed reasonable could seem like an insincere person, such as the millionaire who donated a lot of money to the flood victims. They may be seen as insincere. The reason for this would come from the elites who prefer presenting themselves on television and expect others to know that they were donating a huge amount of money to help people. This situation, on the other side, was accepted as insincere because some elites would like to donate only if they can present themselves to the public. This did not mean all elites who did something like this were insincere.

Therefore, when employing reason, it is important that it is not done so excessively in such a way that someone may seem insincere or even simply becomes boring in the way they communicate and relate to people. Moreover the characters of reasonable people can be distinguished as displaying internal and external characteristics.

'P1: I see. External appearance look a bit serious, and stable, If we look superficially, seem not relax, whatever they think, seem reasonable, whatever they do, seem like no feeling; no feeling such as enjoyment because whoever doing by feeling may have no reasoning, or good, or right, or accepted by others people, because of enjoyableness. But reasonable people will think before doing something, such as, is it good, suitable, what will be the result. They possible think a lot to do a thing.'

However, too much reasoning may be boring for the others.

'E1: Too much compromise and flexibility, if these are not too much, are all right, but if there are too much…there are not acceptable. However, too much reasoning, oneself and others may not have happiness.'

It was quite clear that unreasonable people use their emotions to solve the problem, and they were self-centred.

'P1: Yes, when they angry, they will do something suddenly. Whatever they want to do, they will do because the emotion is the lead. If reasonable people, they will think first, is it good or bad, if the answer is bad, they may not do it. I think reasonable people will think more careful than unreasonable people.'

Finally, the characteristics of reasonable people can be seen as a trusted people; however, using reasoning 'in a reasonable way' or 'within reason' might be more suitable.

5. The differences of reasoning skills between careers

Before going to the central issue, the major suggestions from the students can be divided into two groups. The first was people will have reasoning skills or not, that do not depend on the programme that they have studied but depend on the individual.

'C2: I think they are using the same level because using reasoning skills depends on the individual person, it does not depend on the programme. People in each programme may have or have not had the reason at the same level. It depends on the individual.'

The second suggestion, they believed that reasoning skills depend on the programme that they have studied.

'P1: I think it is different because we learn different things and the environment is also different, they grow up differently in society, therefore thinking style becomes a big gap; for example, one problem each career will see different angle, so reasoning must be different. For example, science and art students, art students may see something with their enjoyment and joining more activities, on the other hand, engineer may study a lot of numbers, so they may analyse by logic more than art students. Another example, linguistic students and psychology students are studying in the same faculty; humanistic faculty, but thinking style or doing things are different, different viewpoints.'

The second point of view was supported by the reason that some careers need to work more carefully because they have to take responsibility for human life, such as pharmacist, doctor, and engineer.

'En1: I think it must be used more than the others because it must be cause and result, it seems like when we work, we need to take responsibility for human life, both causes and the following result.'

Moreover, the work process can influence reasoning skills. Some careers require people to think about causes and effects and prove by science process; however, some careers may draw more on imagination and do not need science process.

'En2: I think we use reasoning skills more than art-career because of different learning, so, thinking may differ. My career have to find the causes, then codify as science; while artist may learn to dance and do it but I learn to calculate, find the causes, and results, because we follow the procedure, conclusion, everything, have to use reasons, such as experiment.'

Even though there are two opinions amongst the students related to whether reasoning skills may or may not be specifically related to the career in which they are working, it may be simply related to the individual; however, most point of views agreed that a career in art needs reasoning skills less than the others.

6. Problem solving in the future

It was an expectation that after the students have graduated from the university then they will go to work. One thing that every one cannot avoid is the problems which may occur from the job or from the co-worker. The students confirmed their belief that they would have problems when they work in the future; however, they thought they would solve them by themselves or consult someone who has experience. They would adjust themselves for some problems.

'C2: If the problem comes from my co-worker, I have to see what the problem is and what the cause is. Or I cannot adjust myself to go along with them. If I cannot adjust myself, I must adjust myself again. For the job, if I am really stressful or feel like… I do not like this job, I may put up with it for a while to make sure that it is not my aptitude, then I may leave this job.'

They would like to use their knowledge to solve the problem.

'P1: There are many skills working together, Also, it depends on the individual, for example, I learn psychology, I have learnt variety of techniques to use with people to solve problems, because psychology is about human behaviour, and four years of my studying make me absorb the thinking style and behaviour of a person and understand what are the causes of their behaviour, such as background knowledge, living, or environment and what period of times in their life, childhood, or adult, family. Everything is related, so, each problem solving, each psychologist will solve in different ways because everyone has the different background. If I were psychologist, I will look at the problem first, what is the problem, then look at the client that which way I can use. I must understand the behaviour that I am confronting first.'

Moreover, good preparation for the job could reduce the problem.

'E2: If the problem about teaching, I think it is not a big problem because, for example, I am a teacher. I will have plan for teaching, so I can entrust someone to teach follow the plan which I have provided learning aid for them already. They can teach without any problem.'

The problem should not be allowed to stay long because it may affect the job.

'En2: We must consider first, if the problem is hard or easy, then delve into that how we should solve the problem; for example, the problem with co-worker, we should talk to each other first about the problem, what it is, and how hard it is, If we can solve it by ourselves, we will do it; however, if it is too hard, maybe somebody else can help compromise, we should do. We should not let the problem stay like that for a long times because it will effect to the job.'

It is interesting that solving the problem should start from oneself. Controlling the others or changing the others seems more difficult.

‘P2: I will see myself first because I cannot control other people. So, I will adjust myself, for example, I need more times to work, I will give up something else. If I cannot make a clear communication with friends, I will improve myself.’

Concisely, we cannot avoid the problems in the future. Using the knowledge and consulting the experiences people may help to solve the problem; however, good preparation to confront the problem will reduce some inappropriate effect. Moreover, solving the problem should start from oneself.

7. Reasons to select programme for studying

Before examining the data in this section, it is worth pointing out that eighteen years old for a young person is in many ways the age of finding individuality. The researcher has had six years’ experience on teaching young people and found that there are many things the teenagers think about before becoming an adult, such as how to be with other people, how to be accepted, how to take care of themselves, including the career in the future. Their dreams have not come true at that time but they need to consider many factors which mean it is difficult to make decisions because they may not have enough information and less experience. For example, which career is suitable for them seems more difficult because most of the time they were in the school. They may receive some information about the characteristic of some careers from somewhere; however, they have no direct experience from doing that career, which may differ in some respects from the information. Moreover, eighteen year old is an age of dreams. There are many dreams in their mind.

‘E1: firstly, I would like to be a teacher. But when I was young, my dream has changed all the times. Sometimes, depending on the trend.’

However, the most common reason that they gave for selecting the programme to study was liking the character of the subject, the number, the calculation, and liking the character of the job in the future. On the one hand, some selected the programme to study because of considering only whether they liked it or whether there would be a job opportunity in the future. Moreover, some selected the programme to study because they have seen an example from a relative.

‘En1: The reason was, I saw the senior study in this programme and later on he can find a good job, so I would like to get a good job as him.’

Someone accepted that they did not like that subject but they would like to obtain a good job after graduation. Therefore they applied to study in that programme.

‘E2: …I did not intend to select this programme. Because the government will provide job for me if I study educational programme, so I have selected many educational programmes ...’

The reason given above may bring danger for themselves, in a case in which the subject that they are learning is far from their happiness or their aptitude because it might be a hard time for them to put up with something that they are not happy with nearly the whole life.

‘C2: ... And I have chance to practice doing job, and I found that working all the times in the lab is boring because I must do the same thing again and again. So, I think I would like to be a medical detailer who I can go out and see many people. I feel like I do not like doing something the same all the times. So, I like to work with the people rather than being a researcher, which studying chemistry can do that job.’

To sum up, the reason to select the programme to study was whether they liked it and work opportunity; however, doing the job can increase their experience. Eventually, something may be changed.

Conclusion

It was interesting that each group of students had their own tendency in the way they responded to the personality/subject groupings, for example, accounting students, and conventional personality, usually answered the question very briefly. On the other hand, education students and psychological students, social personality, preferred to give very long answers including providing the examples too. On the one hand, engineer students, realistic personality, answered the question not very much at length but direct to the main point. The reason for the difference in the style in answering the questions may refer to the Holland’s vocational choice theory which is each personality has their own characteristic and differs from the others.

The final year students referred to strong personality characteristics in relation to their careers, such as marketing students understood that important skills to learn and to solve the problem was communication, speaking, and listening skills, while engineer students recommended thinking skills, chemical students focused on the reasoning skills, and art students indicated imagination. On the one hand, they applied to study in those programmes because they like them and expected a good job when they have graduated. They knew they will confront problems in some way in the future but they believe they

will cope. The skills they will use to solve the problem may be reasoning skills, experience, consciousness, and human-relationship.

Chapter 6

Discussion

Introduction to the Discussion

After analysing the data, it is time to discuss the results and their implications. The results also need to be related back to some of the literature in order to apply the knowledge to practice and to make suggestions for further investigation. It may be useful at this point to outline the research purposes again to confirm our understanding of this research.

As described in chapter one, this research has two main related objectives: to investigate the influences of academic ability on reasoning skills, and problem solving ability, and vice versa, and to examine whether students from different programmes displayed significant different levels of reasoning skills and problem solving skills.

The broad aim of this research was to help schools, university teachers, and those with responsibility for admissions to develop their policy and practice particularly with regard to issues related to rational thinking and problem solving. This study therefore was primarily concerned with testing the reasoning skills and problem solving ability of a cohort of higher education (university) students from seven different programmes of study. At the same time, information from the GPA (Grade Point Average) related to students' academic ability, and gender was taken into account. Programmes were defined in relation to personalities as indicated by Holland's theory of vocational choice. Therefore, comparing reasoning skills and problem solving ability in relation to gender and in relation to students' programme choices was one purpose. And an exploration of how reasoning skills, problem solving ability, and academic ability (GPA) influence each other was another purpose. The knowledge derived from this study is related to human abilities. It is hoped that the results may stimulate educational institutions to develop policies and practice in relation to reasoning skills and problem solving abilities that are more coherent and relevant to the needs of the modern world. It is also hoped that companies or other organizations will give more recognition to human abilities and individual differences as one important factor when they are managing and seeking to develop their employees. Additionally it is hoped that students or applicants to universities may be given more support and guidance for selecting their career. Moreover, the results from this research will help the academic

system to develop other points of view beyond the traditional approaches that are current.

Discussion

The hot issue in Thailand at this moment other than the protesting in Bangkok is the new universities admissions system. The new centralized admissions system was applied to Thai education since 2009 (The National Institute of Educational Testing Service: NIETS, 2011). It is therefore in its early stages of development. The admissions process has four parts. The first one is Ordinary National Educational Test (O-NET) which is basic knowledge using the same test for all last year high school students. The second is GPAX which is the average of GPA from last six terms before graduating from high school. The third is General Aptitude Test (GAT) which emphasises general skills such as reading, writing, analytical thinking, and problem solving. The last one is Professional Aptitude Test (PAT) which emphasises the ability to study and work in the particular chosen field; for example, mathematicians are required to have perceptual ability, calculation skills, quantitative reasoning, math reading skills; engineer should demonstrate that they have space relations, multidimensional, perceptual ability, calculation skills, engineering reading ability, engineering problem solving ability; and students who wish to follow a course in architecture should have space relations, multidimensional, perceptual ability, architectural problem solving ability (Kasikornthai bank, 2011).

The new admission system has these four main tests. Additionally, the partial relevance to this study is that applying for a place in the university employs different criteria for the different programmes. The reason for this is that it is thought that the different programmes need more or less different skills. For example, students who study in engineering programme may need more logical skills than visual art programme. On the contrary, students who study in visual art programme may need more imaginary skills than engineering programme. The importance of acquiring these skills for the universities' students is not only related to the admission process, but is important after students have graduated from the university. After graduation they normally apply for a job in some company or other institution and the company often requires them to take a test in a range of skills which the company thinks is useful or necessary for that job. For example, an internship in HSBC (Thailand) needs numeracy, verbal evaluation, commercial judgement and strong analytical skills (HSBC, 2011). This idea has been supported by other institutions in other countries. The BBC (2010)

recommended that the general and important skills needed for many employers are communication, numeracy, IT, team working, problem solving, and so on. And the careers advisory service at the University of Kent has suggested that although most employers need nearly the same skills and different levels of particular skills are needed in different jobs and they can assess applicants at any times of applying process (The University of Kent, 2010). Furthermore beyond job requirements for participating in general life, some skills such as reasoning skills and problem solving ability are needed.

This knowledge is a reminder that such skills are one factor that is important for high school students to develop. Also it is the responsibility of the universities to prepare their students to acquire the skills necessary for doing particular jobs when the students have graduated. The skills tested before admitting students to the university is one way of trying to ensure the right ones are selected for the right course; however, which skills are appropriate and how, what level of skill needs to be acquired, needs to be considered further.

As described in an earlier chapter, John Holland, a psychologist from the USA has proposed the theory of career choice and personality types which has been influential since 1966. His view is that the personality of the worker is related to their interest and happiness in working. In this sense, people who have the same personality type, for example an artistic personality, is likely to have the same kind of skills and will be interested in the same type of job with certain characteristics. Holland's theory was used to support the choice of programmes for this study. Therefore, among the skills from many which the universities in Thailand have considered to be important and have requested from students who are applying for a place in the university are reasoning skills, and problem solving ability (Kasikornthai bank, 2011).

The two main research objectives were operationalized into specific research questions and hypotheses.

The research question 1; are the students' reasoning skills and problem solving ability from the same programme the same? is composed of two hypotheses. Hypothesis 1 focused on the reasoning skills, and hypothesis 2 focused on the problem solving ability. The same pattern was used in **research question 2**; do the students' reasoning skills, and problem solving ability from different programmes differ? This was also composed of two hypotheses. Hypothesis 3 focused on the reasoning skills and hypothesis 4 focused on the problem solving ability. To make them easier to understand,

the researcher would like to discuss them by grouping the skills that are reasoning skills, and problem solving ability. Therefore hypothesis 1, and 3 (reasoning skills) will be discussed first, then hypothesis 2, and 4 (problem solving ability) will be discussed.

Hypothesis 1: Students from similar programmes have the same level of reasoning skills.

This research aimed to compare reasoning skills within the same programme choice and between different programmes. .

Holland (1966) recommended six types of personality which were distinguished according to their chosen work environment. He said people who like to work in the same environment usually have the same characteristics. Psychological students and elementary educational students were defined as having the same personality, social personality. Hence, this research compared the reasoning skills between these two cohorts of students. The results on table 4.2 show that the reasoning skills from both psychological students and elementary educational students did not show a statistically significant difference. In others word, the same programme choice according to Holland's theory has the same level of reasoning skills. This finding was supported by Dantzker (2010) who conducted his research focusing on the differences between two groups of career, police psychologists and general clinical psychologists, who worked in the same job. He asked whether there were different work results from those two groups of careers. His research was based on Holland's theory of vocational choice which took the view that those two careers were the same personality. And the results indicated no significant differences between those two careers. His finding confirmed that the same personality have the same skills and ability.

Although those results show that the same programme type according to Holland's theory has the same level of reasoning skills; nevertheless, the different programmes may or may not have different levels of reasoning skills. Therefore the following findings sought to answer this question.

Hypothesis 3: Students from different programmes have different levels of reasoning skills.

Students from the same programme (career personality) had the same level of reasoning skills, consequently, it was reasonable to assume that the level of reasoning skills differed from one programme to another. The results from table 4.11 show that they were different for some programmes. The accounting students (conventional) had

the highest level while visual art (artistic) had the lowest level. The group can be sorted from the highest to the lowest as follows; accounting (conventional), education/psychology (social), engineering (realistic), chemistry (investigative), marketing (enterprising), and visual art (artistic) respectively.

The results above can indicate that students have different levels of reasoning skills especially in different programmes, or career groups. This knowledge has potential benefit to the universities' admission system. As described earlier, the Thai universities set up their new criteria for the new admission system in 2009. They have tested students' reasoning skills in many programmes such as engineering programme, accounting programme, economics programme, physical science programme, commerce programme (The Central University Admissions System: CUAS, 2010). Knight and Trowler (2000) have found that the requirement for critical thinking skills between different academic subjects may differ and this difference can vary between individual teachers within one department. Therefore, it might be more useful if the schools are conscious of this situation and embed reasoning skills in their curriculum or provide some courses for the students to practice and increase reasoning skills. Meanwhile students should prepare themselves for applying for a job in the future too by developing their reasoning skills

Not only reasoning skills but problem solving ability (the subject of the next two hypotheses) is also a new ability that the 2009 admission system in Thailand has tested. High school students who would like to receive a place in some programmes in the university, such as science programme, engineering programme, agriculture programme and medical programme are tested. As the career personality theory of Holland recommended that the same personality should have the same characteristic. Therefore, problem solving ability is one of characteristic of human which might be useful to study deeply.

It is noticeable that some of the most successful people in business, government, or some careers, and in life, are those who have the capabilities to solve problems correctly and effectively. It is reasonable that if someone can solve the problem correctly, they may have less trouble than someone who cannot solve the problem correctly. Then those people can receive a positive outcome from their ability, including the success in their career or their life.

The importance of problem solving ability has been recognized for a long time. The psychologist Piaget has recommended that it was possible to notice the behaviour of young children in terms of the quality of their reasoning skills and the way they solve the problem when they confront with it (Piaget 1958, cited Whitebread, 1993). However, the general theory of problem solving was outlined by Newell, Shaw, and Simon (1958) which focused on how people responded when they were confronted with strange situations. Their initial work focused on abstract problems; for example, proving the theorem on logical puzzle and solving the Tower of Hanoi puzzle. The strategy to solve the problem became more precise when Osborn (1963) wrote a book; Applied Imagination, which is about brainstorming.

Later, a variety of strategies to solve the problem was created. For example, Bank (1992) suggest six steps to problem solving; 1) identifying the problem, 2) identify the cause, 3) generate solutions, 4) choose solution, 5) implement solution, and 6) evaluate outcome. And Buchanan and Boddy (1992) suggest nine stage model; 1) identifying the problem, 2) gather data, 3) analyse the data, 4) generate solutions, 5) select solutions, 6) planning implementation, 7) implement solution, 8) evaluate implementation and outcome, and 9) continue to improve. Until the present period of time, there were some experts who suggested strategies to solve the problem, such as, Rambaud (2006) proposed the Eight Disciplines Problem Solving which is used in the Ford Motor Company.

It seems like those strategies were created to solve systematic problems. On the one hand, the qualitative data of this research suggested that in the case of emergency problem, good relationship can help to solve the problem together with intelligence and emotional intelligence.

Generally, when people think about problem solving ability, they imagine a variety of problem situations such as social problems, economic problems, life problems, political problems and so on. However, the problems in this research were a kind of logic and applying ability. The purpose of the test was to evaluate the ability to pass through those problems. Also this research focused on one thing that can provide extra knowledge to the reader. That is the programme (career personality) is or is not associated with the problem solving ability. Thus, the problem solving ability between the similar programmes was compared and the problem solving ability between different programmes was compared.

Hypotheses 2 and 4 are about the problem solving ability between the similar programmes and between different programmes.

Hypothesis 2: Students from similar programmes have the same level of problem solving ability.

The problem solving ability was tested in the same way as reasoning skills. It was also examined within the similar programmes and compared between different programmes. The result of comparing problem solving ability within the similar programmes/same career personality; table 4.4, found that the problem solving ability between elementary educational students and psychological students was not a statistically significant difference. As with reasoning skills, the same career personality demonstrated the same level of problem solving ability.

However, problem solving ability may or may not differ between the different programmes. For that reason, the hypothesis 4 was tested.

Hypothesis 4: Students from different programmes have different levels of problem solving ability.

Table 4.13 shows that problem solving ability differed between programmes. The level of problem solving ability can also be sorted from the highest to the lowest as follows; engineering (realistic), chemistry (investigative), accounting (conventional), psychology/education (social), marketing (enterprising), and visual art (artistic) respectively. However, only problem solving ability from visual art differed from the others, except marketing. Holland said people who are classified in artistic personality normally understand the problems in artistic context, use artistic talents and personal traits to manage the problem which differed from the realistic personality; the highest level of problem solving ability. People who are classified as realistic personality, Holland said, preferred concrete, practical, and structured solutions or strategies rather than clerical scholarly or imaginative solutions.

Besides, the confirmation of the theory, this knowledge can provide some advantage to educators. For instance, the result from this research that confirms the differences in programmes can help educators have more confidence to manage the admission system. It can confirm that some programmes such as engineering needs to test problem solving ability and include that in their criteria; however, it may not be as

important for arts programme to test problem solving ability, according to this research result.

This knowledge also shows us some characteristics of problem solving ability whose importance should be realized by the universities admission. Both in admission system and job selecting which need to test the candidate's aptitude for the purpose of problem solving ability, this finding can confirm that there are some problems solving abilities different between different programmes. Therefore, a personnel manager or anyone who is involved with the accepting of workers can select the suitable people to their job and can manage someone effectively afterward.

Overall, it might be more useful if the universities are conscious of this situation and provide some courses for the students to practice and increase reasoning skills and problem solving ability and embed more reasoning and problem solving in their normal teaching. Meanwhile students should prepare themselves for the job applying in the future too.

This research has collected the data from both genders. It would help to develop more knowledge if the comparison between them were investigated.

A variable called 'sex role' remains important in the fields of psychology and sociology (Lenney, 1991). The interest in this variable began since Terman and Miles published the first masculinity-femininity test in 1936. From there to the early 1970s, males and females became obviously opposite poles. Tests, at that time, often called M-F tests and tester whose score fell between those two extremes were considered as an entity of male and female. Though, later, this concept had some controversies. Constantinople (1973) reviewed the M-F tests and found the relationship between masculinity and femininity had been artificially constrained. This argument was supported by Bem (1974). Bem has designed the Bem Sex Role Inventory (BSRI) for providing independent measures of the individual's masculinity and femininity. And he found that between the two poles, male and female, some people have balanced levels of traits from those poles and were called androgynous. Even though the androgynous become more precisely observable at this moment than the past; however, the majority of people still stay with a concept of gender. Therefore the differences between genders are not insignificant issues.

Research Question 3: Do the students' reasoning skills, and problem solving ability from different gender differ?

Hypothesis 5: Male and female had different reasoning skills.

It is true that there are differences between males and females; for example, physiology is one obvious difference. Some writers have argued that there are not only physical differences, but also mental differences. Shakeshaft (1989) described one difference between men and women is how they make decisions. She found that women generally use compromise style to make decisions, on the other hand, men preferred to use unilateral style. Table 4.14 presented that reasoning skills between males and females were different with males having reasoning skills at a level higher than females. Valentine (1998) noted that the differences between genders were that women have the characteristic of being emotional and sensitive to function outside of domestic roles. The view has also been expressed that males have more reasoning skills than females and that this can be seen when they work. Gilligan (1993) recommended that women tend to view work as a network of relationships while men view work as a logical or task oriented fashion. In the education system, however, Jeske (2004) suggested that equal education for girls/women would improve their reasoning skills. This is an important argument because it suggests that the degree of reasoning skills shown by males or females may be due not to nature but more to do with the social environment, their upbringing and even formal education.

Hypothesis 6: Male and female had different problem solving ability.

Table 4.15 shows that problem solving ability between males and females was not different. From this data it is clear that not all things differ between males and females. Although problem solving ability between male and female was not different; however, according to some of the literature, the approach to solving problems may differ. Beyer (1998) observed the differential strategies in dealing with conflict of men and women. He found that women were inclined to use avoidance strategies, minimizing differences and smoothing over problems. Men were inclined to use more direct and competitive approaches. Continually from this issue, Fitzgerald and Betz (1994) called for the need to revise the existing career theories to support information on women's issues. And Peterson et al. (1996, p. 423) pointed out the way to increase people's ability by 'helping individuals become skilful career problem solvers and decision makers throughout their lives'.

Overall, the issue of male and female having different reasoning skills but problem solving ability does not differ may suggest that some careers may be suitable for males more than females. On the other hand, some careers may be suitable for females more than males. This research found that the samples from accounting programme has the highest level of reasoning skills, as the same time, comparing between male and female found that male has reasoning skills level higher than female. As a result, this implied that males can work with accounting better than females. This is a controversial suggestion; however, the implication may be that the education system needs to prepare females so that they are equally suited to a career in accounting.

The next part of the investigation the researcher would like to draw attention to is how reasoning skills, problem solving ability, and academic ability influenced each other. The comparison of those variables can provide some knowledge about reasoning skills, and problem solving ability. To understand more about them, how they influenced each other, structure equation modelling analyses was employed.

Education is important from the past to the present; for example, Thailand has started education by passing on information from parents to children or from monks to boys, the girls can learn cooking from their mother (Ratmanee, 2010). Until the present time, the education has seen very clearly in the school or university, and they provided many subjects for the learners to select. Due to the society becoming wider and more complicated than the past, consequently education becomes an indicator or certificate to guarantee the ability of people. For example, people who graduated in art should have ability about the art more than others, people who graduated in law should have the knowledge about the law more than others. If considering only in the school of law, people who have received the higher score should have higher law ability than people who have received the lower score. Therefore, the score, GPA, or academic ability is one variable which is important to study.

The Ministry of Education, Thailand, (2008) announced that the purpose of education in Thailand is to increase the knowledge, communication skills, analytical thinking (reasoning) skills, problem solving ability, use of technology, and life skills. For that reason, the purpose, partly, of education is the knowledge and ability to work of the learners. And also the ability to solve problem is another variable to study. Furthermore, Mazuro (2006) indicated that one main purposes of higher education is to encourage students to improve the critical thinking skills or reasoning skills.

Research Question 4: Do the reasoning skills, students' problem solving ability, and academic ability influence each other?

There are many factors that may be involved with each other, such as reasoning skills, problem solving ability, and academic ability. In the interviews the students thought that the core skills that helped them to improve their academic ability would be diligence, concentration, intention, thinking skills, and being interested, and the skills identified to solve the problem may be reasoning skills, experience, consciousness, and human-relationship, while there are some reasons to say that reasoning skills related to problem solving; however, they were not sure that reasoning skills related to learning ability. Therefore, the influences between reasoning skills, problem solving ability, and academic ability were investigated.

Hypothesis 7: Reasoning skills were influenced by problem solving ability and academic ability.

The reasoning skills were examined to find out the influences between itself and problem solving ability, and between academic ability. And the results on the figure 4.3 show that problem solving ability influenced reasoning skills and academic ability influenced reasoning skills too. It was estimated that problem solving ability and academic ability, both, explained 30 percent of reasoning skills variance by correlate to problem solving ability approximately 27.67 percent and correlate to academic ability approximately 2.69 percent. This result informs us that the change in the reasoning skills result relates to problem solving ability; for example, assigning the students to practice solving the problem, by 27.67 percent; on the other hand, learning academic subjects can induce a few changes by 2.69 percent on reasoning skills. The other 70 percent must come from other factors. Wright (1991) said teaching style, students preferred a flexible disclosure from both teachers and themselves and this flexible disclosure can encourage the improvement of integrating skills which needed to enhance reasoning skills. While the reasoning skills are needed by the employers (Mazuro, 2006) and it is clear that one purpose of students is to get a job after graduating (Tynjala, Vaalima & Sarja, 2003), therefore, the educators and the educational institute need to think about making sure that students practice problem solving ability to increase their reasoning skills. It is not enough to focus on teaching to develop just academic ability without also understanding the development of reasoning skills.

Hypothesis 8: Problem solving ability was influenced by reasoning skills and academic ability.

Problem solving ability was influenced by reasoning skills and academic ability. The dimension of reasoning skills regression weight showed a positive influence on problem solving ability (.54). Conversely, the regression weight of academic ability showed a negative influence on problem solving ability (-.07), in other words, when academic ability increased, the problem solving ability decreased. It was estimated that problem solving ability variance was 28 percent explained by academic ability and reasoning skills. However, Sean (2010) indicated that cooperative learning may have been one factor which can increase problem solving ability. Data also suggested that students liked working cooperatively, and this exposed students to other problem solving strategies, and helped them understand word problems better. Long and DeTemple (1996) suggested that problem solving ability was not inborn, it must be taught. In Thailand, Pimta, Tayruakham, and Nuangchalerm (2009) conducted the research on one thousand and twenty eight of sixth grade students, and found that the factors influencing mathematic problem solving ability were attitude towards mathematics, self-esteem and teachers' teaching behaviour.

This means the present learning and teaching style for the participants in this research needs to be considered and adjusted because this style is not improving the learner problem solving ability.

Hypothesis 9: Academic ability was influenced by students' problem solving ability and reasoning skills.

This hypothesis was focused on variables which may be involved with academic ability, and it was focused on problem solving ability and reasoning skills. The results showed that the dimension of reasoning skills regression weight was positively related to academic ability (.21); and, regression weight of problem solving ability was negatively related to academic ability (-.09). It was estimated that academic ability variance was 3 percent explained by problem solving ability and reasoning skills.

The result of this study shows that the problem solving ability had a small influence on academic ability and it was in the negative direction (-.09). The result might encourage Thai educators to think about how to teach students in Thailand. Woolfolk (1995) said the psychologists believe that teaching with implementation of problem solving can increase students thinking skills. Corresponding with, Kamaruddin

and Hazni (2010) who surveyed their students and found that eighty percent of their students would like the teachers to include problem solving methods into the modules or textbooks and classes because they believe that this method can help them with their studies. Md Kamaruddin and Hazni suggested that the problem solving ability is very important for students because it can train students to think and find the solutions systematically and logically. They also recommended that the educators should not only teach knowledge but should teach students how to learn and think too. Meanwhile the negative direct effect from academic ability to problem solving ability confirms that Thai education system at this moment does not improve the problem solving ability. Fortunately, the current system in Thailand may improve some reasoning skills (positive direct effect) and this may improve problem solving ability in indirect way.

To sum up, this research found that there were different levels of those factors found in different programmes. Therefore, this result would remind the educators to think about their curriculum, and admission system. The research result also indicated that reasoning skills related to the problem solving ability by 27.67 percent; on the other hand, academic ability may not relate to the problem solving ability, nearly zero percent. This knowledge was worrying the researcher about Thai education system because the aim of education is to build the students to have ability to solve the problem when they grow up. This research investigation showed that the ability to solve the problem was not related to academic ability. This is important because it reinforces the role that university teaching has to play in developing problem solving ability in students of all abilities.

On the positive side, the research result can inform the educators to think about what is in the job market needed. In some careers, they need more reasoning skills and problem solving ability; for example, accounting, banker. Thus, the educators can prepare their students in advance. And also the knowledge from this research may help career counsellors to consider counselees ability while they are consulting. The process of career counselling, normally, is to investigate the interesting of the counselees to the job environments and consider the counselees' abilities at the same times. Therefore, this research result may remind counsellors to think about the different of personalities that may have the different skills.

On the other hand, there were some opinions from the interviewees suggested that skills to learn and skills to solve the problem may have variety. They were not only reasoning skills. And the interesting recommendation was human-relationship can help

to solve the problem. The marketer recommended good communication to solve the problem, which human-relationship and good communication cannot be seen as a logical thinking. It is something else use for solving the problem that sometimes reason cannot explain.

Eventually, it would be more advantageous if further studies focus on the varieties of characteristics of each programme; for example, other skills, personality, and problem solving ability.

Conclusion

The reasoning skills and problem solving ability within the similar programmes (same career personality) were not different; conversely, they were different within the different programmes which lend some support to Holland's theory. Also, the differences between genders did not make everything between male and female differ; for instance, reasoning skills differed but problem solving ability did not.

Academic ability and problem solving ability have very few negative influences on each other. However, there were some influences between reasoning skills and problem solving ability. And there were a few influences between reasoning skills and academic ability.

One inference that can be made from these results is that reasoning skills can be improved by practicing problem solving techniques, and also problem solving ability can be high if people have high reasoning skills. The influences between problem solving ability and academic ability were negative which means that students who have high academic ability might have low problem solving ability or inverse; student who has high problem solving ability might have low academic ability. In the literature review it was shown that in some countries academic ability is a good predictor of reasoning and problem solving but according to this research this is not the case among higher education students in Thailand. As discussed in the introduction (p. 4) international comparison studies found that students from a country that provides a less advantaged background are less advantaged in school and are less advantaged in the way of reasoning and problem solving problem. Interestingly, this idea was said informally for many years in Thailand, for example, the students who really focus on the studying, eventually they will have a high GPA but they may be unable to solve problems well when they work after they have graduated; on the contrary, students who learn and do some activities at the same time, help friends or teachers in some ways, they will have more skills to solve the problems and work with others quite well. This is

similar to Rees and Rees who studied the differences between two groups of pupils who have experiences with problems and do not have experiences with problems. They concluded that

> ‘much may be gained from studying the experiences of young people who have previously presented with affective difficulties but have gone on to become successful in later schooling’ (Rees & Rees, 2001, p.61)

This idea was supported by Eva. (2010) He explained that

> ‘we encounter a lot of problems in our day-to-day lives and, unless a new problem is similar enough to a relevant old problem as to prompt both its recollection and awareness of how the solution can be adapted, that previous experience is unlikely to be of much help.’ (pp. 27-28)

The qualitative data provided some opinions that most interviewees did not identify reasoning skills as a factor which might influence academic ability but they more often recognized the impact of concentration and diligence. On the one hand, they believed that consciousness, experiences, consulting experts, and reasoning skills can help problem solving. And they thought that people who have limited reasoning usually try to solve the problem using more intuition and emotions. They also thought that artistic personality might have the lowest reasoning skills.

Reasoning skills can be seen in both a positive and negative light. In case of a negative perspective, they thought people who have a lot of reasoning seem to be insincere to others. Reasoning as a positive aspect can help people solve the problem and seem more reliable to others.

The reason interviewees selected their programme was because they liked it and the career in the future. Some said they changed a lot of ideas when they were in high school, eventually they chose the favourite programme.

For that reason, the qualitative data showed that interviewees believed that reasoning skills can influence problem solving ability and academic ability but no one thought the academic ability and the problem solving ability related to each other. The reason they selected a programme to study were preference and future career.

In summary, these results have implications for the education system such as admission system, curriculum planning, and teaching methodology. Meanwhile, they remind students to prepare their skills before going to hunt a job after graduation. Moreover, the personnel manager can manage their staff to suit the characteristics of the job.

Chapter 7

Conclusion

At this point in the thesis, it is necessary to reflect upon the aims and objectives of the research, the implications and recommendations arising based on the findings, and its limitations. Suggestions for further research will also be outlined.

An overview of the study

The education in Thailand started in the Christian era 1283 when the king of Sukhothai, Ramkhamhaeng, created the Thai alphabet. There is a gradual expanding of education to include all Thais at this moment, and the average level of education is gradually getting higher. Nevertheless, the numbers of educational institutes, particularly the universities, are still not sufficient to cater for all students, moreover, some programmes that the universities offer to the students which are really needed exceeds the limitations of the universities to support them. The ability of students who are applying for each programme needs to be considered too. For example, students who are applying to the mathematical programme have to have the calculation skills, otherwise they will have difficulty while they are studying, or even worse they will not be able to finish their studying which will lose time, chance for themselves, and chance for other students who should have got those places. Hence, the universities have to set up the methodology and criteria to select the suitable students to the programme. It is called ‘admission’.

The present admission is aimed at selecting suitable students to the programme. One part of the process is to test students’ skills, such as, perceptual ability, calculation skills, quantitative reasoning, and problem solving ability, but not all programmes test the same skills; the different programmes test different students’ skills; this is possibly the right approach if they test the appropriate skills needed for those programmes.

Meanwhile the Ministry of Education, Thailand, (2008) announced that the purpose of education in Thailand is to increase knowledge, communication skills, analytical thinking (reasoning) skills, problem solving ability, technology using, and life skills. Therefore, from the skills that the students have to be tested in, the Ministry of Education would particularly like to increase reasoning skills and problem solving ability which was selected as the focus for the study. Also, it was thought that it would

be more advantageous to the students, educators and educational institutes if academic ability was studied together with reasoning skills and problem solving ability.

It was hoped that this study would have advantages not only for the students and educational system but also for the job selection, career counselor, and personnel manager too. It is clear that everyone will be looking for a job after graduation. Generally, recruitment has some criteria for each job position; for example, the Requaero Limited, UK, has advertised a vacancy, Software Test Engineer, Wireless Chips, located in Cambridgeshire which needs applicants to have working skills including good communication and good problem solving ability on their profiles (Requaero company, 2011). This indicates that some skills are needed for the job application and also for doing the job. The recommendation about the skills for doing the job is not inappropriate because if people work on the job for which they have the right skills, they should be able to work well and be happy with their work eventually. On the contrary, if people work on a job for which they have no skills, they may have difficulty with their work and may not put up with it for long. Therefore, preparing students' skills for the job in advance would be the clever and cautious idea.

Overall, this research focused on the reasoning skills, problem solving ability, and academic ability particularly related to the admission system, the educational system, and job selection.

As outlined in the introduction (p.8) this research had two main related objectives: to investigate the influences of academic ability on reasoning skills, and problem solving ability, and vice versa, and to examine whether students from different programmes displayed significant different levels of reasoning skills and problem solving skills.

The different programmes were chosen in relation to different career personalities, according to Holland's theory of vocational choice. Also, the differences of those skills among the genders were compared. To respond to those objectives, the research methodology was conducted by testing reasoning skills, and problem solving ability of 333 final year students from seven programmes in one university, the sample. Simultaneously, information from the GPA related to students' academic ability, as well as gender was taken into account. The sample was chosen from seven programmes and the choice was guided by divided Holland's vocational choice theory. This gave six categories of programme for the purposes of the research. In addition, 14 students were interviewed for some aspects that the tests cannot address.

The research instruments were the reasoning skills test and the problem solving ability test. The reasoning skills test was adapted from Jittachun's reasoning skills test in Thailand. The test was created by improving the difficulty as the original test was built for 13 years old, whereas the samples for this research are 22 years old, and number of items was increased from 4 items in the original test to 5 items in this research. And the problem solving ability test was applied from the logical puzzles, mathematical puzzles, and real world problems. However, before finalising the real version, the tests were reviewed by four experts, and tried out to select the items which passed the standard test quality. Overall, the quality of the test, content validity, construct validity, discriminant validity, was reported, and the reliability was .633.

After the data was collected, the statistics tests, descriptive statistics, t-test, two-way MANOVA, and structural equation modelling (SEM) were employed to analyse it. The results found that the reasoning skills and the problem solving ability were not different within the similar programmes (same career personality); on the other hand, they were different between different programmes. Male and female students had different reasoning skills; however, the problem solving ability was not different between them. There was some correlation between reasoning skills and problem solving ability approximately 28 percent and there was some correlation between reasoning skills and academic ability approximately 3 percent. On the one hand, there was very limited correlation less than one percent, between academic ability and problem solving ability.

Key Research findings

- Students from the similar programmes (same career personality) have the same level of reasoning skills, and the same level of problem solving ability.
- Students from different programmes have different level of reasoning skills, and have different level of problem solving ability.
- Male and female students have different reasoning skills; however, they do not differ in problem solving ability.
- The relationship between reasoning skills and problem solving ability is about 28 percent; however, the relationship between them and academic ability is less than 3 percent.

Implications and recommendations from the current research

The results from the current study provide some support for the new admission system in Thailand that tests students' aptitude. The admission system tests PAT1 - PAT7 which are the skills that the university thinks are necessary for some programmes and those skills are necessary for students in each programme to study and work in the future. The skills needed for each programmes are different.

Reasoning skills and problem solving ability had some part in some PATs and also were in the general aptitude test (GAT) which students have to take. However, it is not clear which programme needs the test and how strong those skills feature in each programme. For example, they assign the engineer candidate to take PAT3 and PAT2 whereas some people argue that the candidate should take PAT3 and PAT1. See the detail in the next paragraph.

The Association of University Presidents of Thailand, AUPT, take charge of the Central University Admissions System, and they assigned the ratio of four maim factors for this central admission. That are GPAX = 40%, O-NET = 30%, GAT = 10-50%, PAT = 0-40%, all together = 100%. PAT has 7 subclasses; PAT1(mathematics potential), PAT2(science potential), PAT3(engineering potential), PAT4(architectural potential), PAT5(educational potential), PAT6(art potential), PAT7(foreign language potential). To prevent the different universities from using different criteria, therefore, they assigned the details from each PAT for all universities to use the same criteria, such as accountants have to take PAT1, nurses have to take PAT2, engineers have to take PAT2 and PAT3, architects have to take PAT4, educators have to take PAT5, artists and musicians have to take PAT6, and for any programmes relate to language they have to take PAT7. The AUPT gave a chance for all faculties to consider these criteria and express an opinion. Nearly all agree with this criteria, except the council of engineering department of Thailand, Dr Pakorn Watanachaturaporn, the vice dean of department of computer engineering , faculty of engineering , King Mongkut's Institute of Technology Ladkrabang, called for replacing PAT2(science potential) with PAT1(mathematics potential) and remaining PAT3(engineering potential) (Daily News, 2009). However, the AUPT confirmed to use their old criteria. Therefore, the criterion is still the same even if some professionals have had some disagreement.

The admission system seems to be related to this research results in the aspect of different programmes need different skills, otherwise different levels. This research found that final year students have the different level of reasoning skills which can be sorted from the highest to the lowest as follows; accounting, psychology/education,

engineering, chemistry, marketing, visual art. And these students have the different level of problem solving ability which can be sorted from the highest to the lowest as follows; engineering, chemistry, accounting, psychology/education, marketing, and visual art respectively. These can imply that students who would like to receive a place in, for example, accounting programme ought to have the reasoning skills score higher than the other students in other programmes. The new admission system should investigate more deeply about the skills of students that are really needed for each programme because these skills will relate to doing the job in the future too.

While the Ministry of Education, Thailand would like to increase some skills and some abilities of the students such as the knowledge, communication skills, analytical thinking (reasoning) skills, problem solving ability, technology using, and life skills, this research found that there were differences of reasoning skills and problem solving ability between some programme which means some students have more skills than others. For that reason, the Ministry of Education should consider that they are acceptable or not, otherwise they can study more how to increase those skills.

Fortunately, this research has studied the relationship between reasoning skills, problem solving ability, and academic ability, and found that reasoning skills and problem solving ability had some influences on each other. As a result, increasing reasoning skills can be done by practicing to solve the problem, and inverse, when the reasoning skills increase, the ability to solve the problem will be increased too because they had the influences between each other. Conversely, the research results show that academic ability had no influences on the problem solving ability and had a few on the reasoning skills. This is an important finding because it differs from some of the research reported from other countries in which academic ability is a good predictor of reasoning skills and problem solving ability.

Some of this research was reported in the literature review. Tobin and Capie (1982:113) found that ‘formal reasoning ability was positively related with rates of generalizing and comprehending’. Bird (2010) examined the logical reasoning skills of students enrolled in General Chemistry at the University of Puerto Rico. This information was used to determine which logical reasoning modes were the best predictors of student performance in the general chemistry course. In Cyprus a study by Valadines (1997) looked at the relationship between reasoning and academic performance and also quotes a range of other research studies that show that formal reasoning abilities have been identified as essential abilities for success in advanced science and mathematics courses. Bunce and Hutchinson (1993) the GALT test (of

reasoning) could be used to identify students at risk of failure regardless of the level of chemistry taught. They suggested the GALT tests had the advantage of being easy to administer. They found the tests even more effective as a predictor in nursing and non-science major courses. They point out the fear that test scores will be used as a barrier for admission to a course or as a 'weed out' instrument and that no single predictor is fool proof. Gustin and Corazza (1994) analysed the relative contribution of age, gender, and verbal and mathematical reasoning abilities (measured by subtests of the Scholastic Aptitude Test) as predictors of success in accelerated secondary science courses. They found that a composite of verbal and mathematical reasoning ability was the most powerful predictor and verbal reasoning ability was the strongest single predictor.

In contrast the research in this study showed that reasoning and problem solving was not a good predictor of academic achievement.

There are two related explanations for this finding. One is that the examination testing system that yields the measure of academic ability does not address reasoning and problem solving ability sufficiently. The other is that the present education system may not be doing enough to improve the reasoning skills and problem solving ability of students. The high GPA cannot guarantee the high reasoning skills and the high problem solving ability. Teaching at this moment does not appear to increase the expected skills that the Ministry of Education has announced. The recommendation for this issue would be that teachers should embed reasoning and problem solving more in their teaching and an additional subject that relates to the problem solving ability and using logical skills might be considered. The importance of having some subject to develop problem solving ability and reasoning skills in school has been supported by Burgess (2010, p.1). She has called for making reasoning skills compulsory in schools in the UK.

> 'we believe introducing Philosophy lessons in the classroom from a very early age would have immense benefits in terms of boosting British school kids' reasoning and conceptual skills, better equipping them for the complexities of life in the 21st century where ubiquitous technology and rapid social change will be the order of the day.'

These research results can apply to the job selection, both applicants and recruiters, and also career counsellors. The starting point of the application should begin from the secondary school. Teachers should provide some advice about the programmes in the universities to the students which relates to the career in the future. In general, the secondary schools have the duty to prepare background knowledge for all secondary

school students; however, these students have to make decisions what to do or what to study after finishing their studying from the secondary school. Some of them may think about doing a job but most of them will apply to the university to study further. It would be an advantage if the secondary school guides their students about the career in the future. Even if they are going to study further or do a job, the school can look into students' skills and provide them the relevant information. That does not mean forcing the students into one career path but it does mean giving them as much information to help them make choices. In the case of students who would like to study further, they will apply for a place in the university. Selecting the suitable programme is important because it is relevant to their career in the future. The success of their career has started from this point. If they choose the suitable programme for themselves, they will have an attentiveness to learn in the university and to work in the future. This research has recommended that each programme needs specific skills with possibly some skills needed from many programmes. Consequently, the secondary school can invite some information about reasoning skills and problem solving ability from this research together with other skills' information to inform the students.

The next responsibility would be the university. After the students have obtained a place from the university, they will study about specific knowledge which is expected to use for working in the future. Normally the university teaches them academic knowledge as academic teaching is the universities' main duty. In the meantime, the Ministry of Education, and the market force would like the graduated students to have some other skills to work such as reasoning skills and problem solving ability. For that reason, the universities should consider their teaching how to improve the students' working skills. They should also consider whether the assessment methods reflect sufficiently an emphasis on reasoning and problem solving. This research result shows that academic ability did not relate to problem solving ability and approximately 3 percent to the reasoning skills which suggests the present teaching style does not appear to be increasing problem solving ability and reasoning skills. The recommendation for this issue would be the same direction as the previous one, creating some practicing problem solving techniques to increase the reasoning skills. The result will increase both reasoning skills and problem solving ability, according to this research results.

Recommendations

For educator

- The aims of learning and teaching may need to be revised to improve the skills which are necessary for working after graduation.
- Assessment methods need to be examined to determine whether there is sufficient emphasis on reasoning and problem solving.
- Policy about working skills needs to be clear and coherent.
- Curriculum needs some subjects to increase working skills, or some skills which are necessary for life.

For teacher

- Teaching methodology and technique may need to be revised to increase the reasoning skills, and problem solving ability.
- Secondary school teachers should guide students about job characteristics. And provide them the skills test, such as, reasoning skills test, problem solving ability test, personality test, and so on.
- The culture of teaching and learning in the classroom should provide more opportunities for students to discuss and show the reason to the teachers.

Limitations of the study

There were some limitations with the research that should be made explicit. Some were associated with the area of sample sampling; the sample in this study was selected by purpose from one university which may not represented the most students in Thailand; however, if considering that the students in this university can possibly come from everywhere in Thailand, the representation of the population may be seen better. The literature review revealed that in some countries academic ability is a good predictor of high levels of reasoning skills and problem solving ability. This helps employers because these skills are important for future jobs. However, this research suggests that in Thailand academic ability is not a good predictor. This is in keeping with the literature review which examined the history of education in Thailand and the cultural attitudes to learning. The tradition of passive learning in Thailand means that reasoning and problem solving have traditionally not been given a high priority. Recent

government initiatives have emphasized the importance of these skills but according to this research there is still some way to go in pursuit of this aim.

Another limitation was the reliability of the test which was not too high. (α = .633) Wells and Wollack (2003) advised that it can be improved by increasing the test length and items quality. Meanwhile, the tests for this research may not be the standard tests which can be used anywhere in the world; however, the content of the test was approved by four experts in Thailand so that the tests may be more suitable for Thai people. The different kinds of validity normally applied in research are all important. Which one should we select to use in our thesis depends on the characteristics of the thesis. For example, the thesis which has strong involvement with theory needs construct validity rather than others, whereas the thesis which has strong involvement with people may need content validity rather than others. I placed emphasis on face validity in my study because of the cultural context; I wanted to ensure that the study was thought to be suitable by Thai experts. However this is clearly a limitation because there is no guarantee that other experts would necessarily judge the test in the same way. The qualitative data has its own limitations. There were fewer respondents so this inevitably limits the possibility of drawing conclusions. The results from qualitative interviews depend on the clarity of understanding between researcher and respondent. There is also room for misinterpretation at the analysis stage. Meanwhile type I or type II error will be considered when quantitative data were analyzed. Therefore this thesis analysis did not confound between two types of data.

Suggestions for further research

First of all, if it is possible, the further research should be aware of the same limitations as this research. However, this research has contributed some knowledge which the further research can extend such as there were no relationship between learning ability and problem ability. This research investigated the influences between those skills but did not study how to improve their influences. As a result, further research can experiment with some variables to improve their relationship. On the one hand, reasoning skills and problem solving ability were related to each other, therefore, problem solving style can be investigated on the purpose of which style can gain more reasoning skills, and the problem solving ability will be increased by itself. Otherwise, trying to teach an extra subject, such as, solving problem with reasoning, in school or in the university would be interesting.

For the aims of admission system, the others skills which the new admission in Thailand requires to test the students can be investigated for all programmes, and how much they are needed. Also the standard score can be set up if testing from the mass population.

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Appendix A

Test

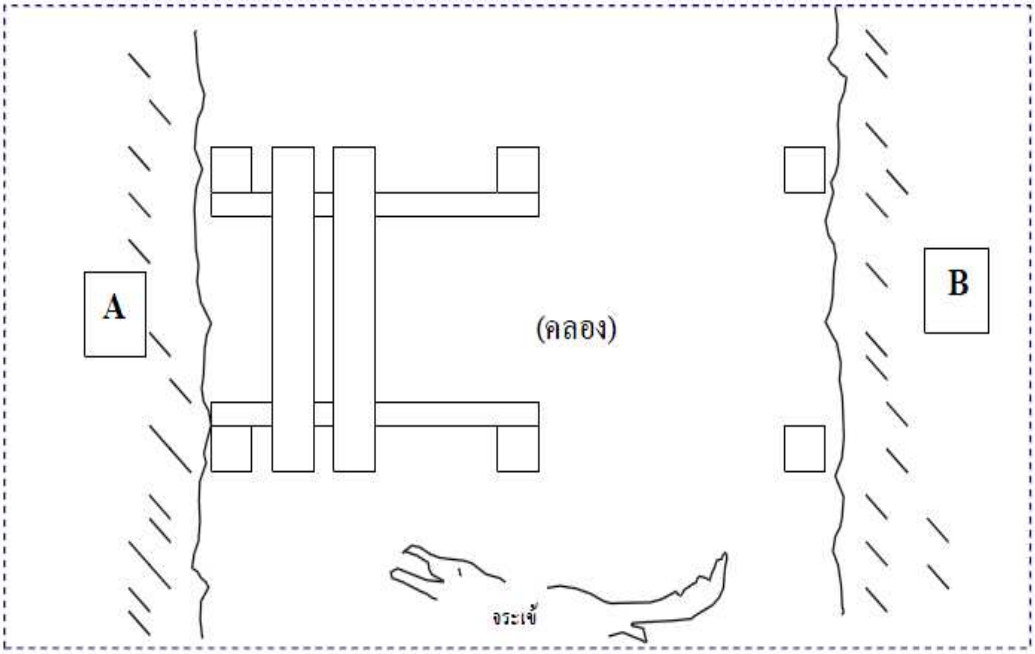
This document is a thinking skills test, used as a tool for doctoral degree research. Would you please consider carefully before answering? Your answers will be used only for the benefit of the research, they will keep them confidential and will effect nothing with you.

- Your gender ……..
- Your last GPA …….

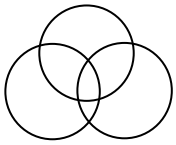
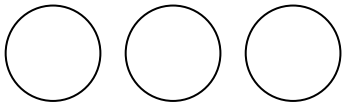
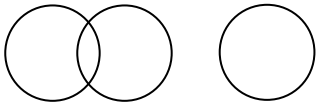
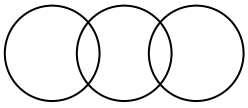
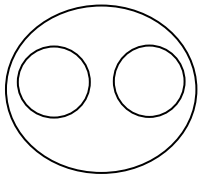
Item	Instruction: Please select a choice which has correlation the same with the given word before
1	duck : egg ⇒ butterfly : ? chrysalis caterpillar worm parasite tussock moth a. b. c. d. e.
2	shark : fish ⇒ eagle : ? snake bird fish rat carcass a. b. c. d. e.
3	paper : pencil ⇒ computer : ? keyboard monitor CPU speaker microphone a. b. c. d. e.
4	toothbrush : toothpaste ⇒ ? : ? hammer : nail spoon : fork male : female paintbrush : paint a. b. c. d. washing machine : detergent e.
5	painting : painter ⇒ ? : ? song : singer meat : cook student : teacher child : father book : writer a. b. c. d. e.
Item	Instruction: Item 6 - 7 *please select a choice whose its character differs from others*
6	A B E I O a. b. c. d. e.
7	BW FJ KR PY VT a. b. c. d. e.
	Instruction: Item 8 - 10 *please select a choice whose character is the same as given*
8	£50 £20 £10 … £5 £1 50p 20p 10p a. b. c. d. e.
9	Tiger Leopard Lion … Elephant Horse Giraffe Wolf Deer a. b. c. d. e.
10	Plane Bus Train … Tractor Crane Ferry Horse Bicycle a. b. c. d. e.

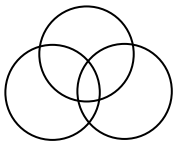
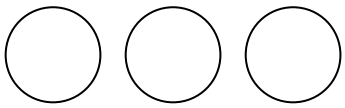
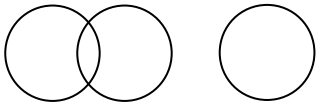
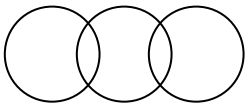
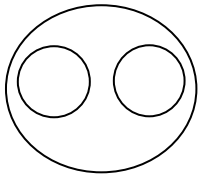
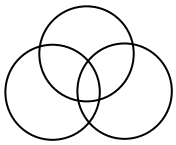
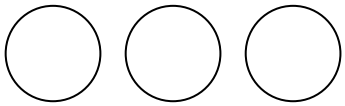
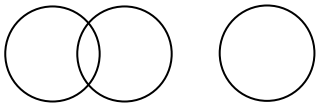
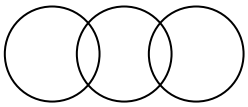
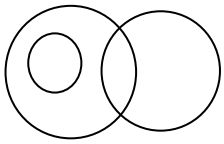
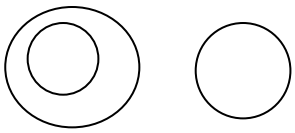
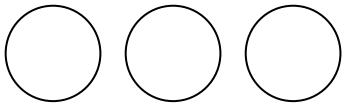
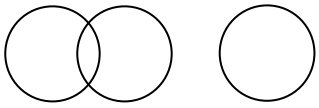
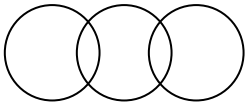
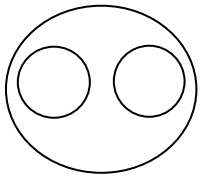
11	Please explain how you can cross the river with only one animal at a time while you have a dog, a duck, and a chicken with you. You cannot let dog stay with any animal without you.

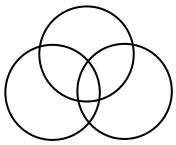
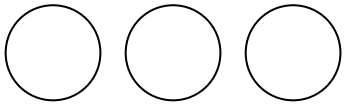
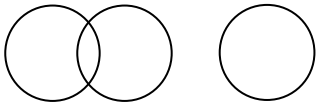
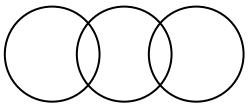
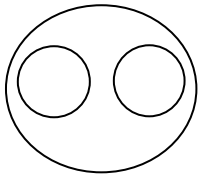
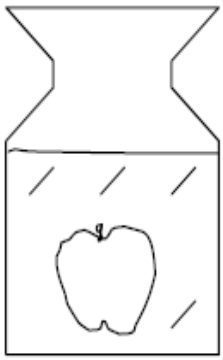
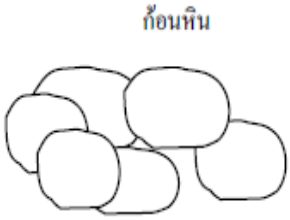
Item	Instruction: Item 12 - 16 *please find the conclusion from the given premises*
12	Students who concentrate on the studying will get good score. Sean and Andrew get high score but Tom and Peter get low score. John who is studying in another school concentrates on studying for university entry next year. Which conclusion is correct? a. Andrew concentrate on the studying. b. Tom does not concentrate on the studying. c. Tom can centrate on the studying less than Sean. d. Sean and Andrew concentrate on the studying the same level. e. John will get good score.
13	Some students can pass the test if they study hard. Tom studies hard; however, Sean studies harder. Tom's brother has graduated last year. Therefore … . a. Tom can pass the test. b. Sean cannot pass the test. c. Tom's brother can pass the test. d. Tom and Sean can pass the test. e. Cannot conclude.
14	All birds can fly. Eagle is a bird. Bat is not a bird. Therefore … . a. Bat cannot fly. b. Eagle can fly. c. Both can fly. d. Both cannot fly. e. Bat can fly.
15	Pets can live with human. Some cats are pets. Mimi is a cat. Tom is not a cat but Tom is a pet. Therefore … . a. Mimi can live with human. b. Mimi cannot live with human. c. Tom can live with human. d. Tom cannot live with human. e. Both can live with human.
16	If a snake bites a dog, the dog will die. If a dog bites a snake, the snake will die. Tommy is a dog. Luzy is a cat. In the morning, Luzy and a snake died on the yard. Therefore … . a. Luzy was bit by a snake. b. Snake was bit by Luzy. c. Snake was bit by Tommy. d. Luzy and snake bit each other. e. Cannot conclude.

17	Would you please rebuild the bridge (from the picture) for people crossing the river from A to B? 

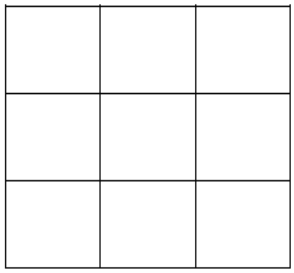
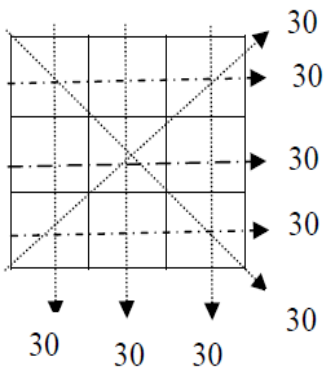
Item	Instruction: Item 18- 22 *please select a choice which can be in the series.*
18	12:25, 13:00, 13:35, … a. 14:00 b. 14:10 c. 14:15 d. 14:30 e. 14:45
19	Go to market, Buy an apple, Go home, … a. Eat it b. Throw it away c. Sell it d. Clean it e. Peel it
20	A, C, F, J, … a. B b. K c. L d. M e. O

21	1, 2, 6, 15, 31, … a. 45 b. 56 c. 64 d. 100 e. 128
22	49, 14, 36, 12, 25, 10, … a. 18 b. 16 c. 14 d. 10 e. 8
23	How can you move a too heavy book bag up to the second floor in your house without any help?
Item	Instruction: Item 24- 28 *please select a diagram which shows relationship of the assigned words.*
24	Computer, Keyboard, Mouse(computer device) a.  b.  c.  d.  e. 

25	Mattress, Pillow, Blanket a.  b.  c.  d.  e. 
26	Flower, Door, Vast a.  b.  c.  d.  e. 
27	Pomelo, Guava, Mangosteen a.  b.  c.  d.  e. 

28	Table, Chair, Desk a.  b.  c.  d.  e. 
29	How can you get an apple if you do not want your hand to get wet? In that area has only small branch and stones. (see picture)   

Item	Instruction: *answer question 30 – 34* Mr A, the first child of Mrs B and Mr C, has 3 children; Mr D, Mr E, and Mr F respectively. The youngest child of Mrs B is Mrs G; who married Mr H, has one daughter; Miss I. On the one hand, Mrs G'sister; Mrs J, has only one son; Mr K. Mr K'aunt love him a lot but Mr A'brother does not love Mr K because he does want to study. (For question 30 - 31)
30	Who is Mr K'aunt? (Thai langue; aunt and uncle use the difference word if they are older or younger parent, for example, who younger than father called Are, younger than mother called Na) a. Mr A b. Mrs G c. Mr F d. Mr C e. Miss I
31	Which arrangement from the oldest to the youngest is correct? a. Mr C, Mrs J, Miss I b. Mrs J, Mr A, Mr K c. Mr F, Mr K, Miss I d. Mr A, Mr C, Mr F e. Mr E, Mr F, Mr K
32	A six persons' lift move from the first floor to the sixth floor. On the second floor, there is a person gets into the lift, two people get out on the third floor, one person get in on the fourth floor, two people get out on the fifth floor and no one get out the lift on the sixth floor but five people get in and the lift is full. How many people get into the lift on the first floor? a. No one b. 1 c. 2 d. 3 e. 4
33	$A \leq B = C \neq D$ Which conclusion is 100% true? a. $A = D$ b. $A \neq D$ c. $A < C$ d. $A = C$ e. $B \neq D$
34	Please select a choice which true by this condition. Condition: $A > N \leq B < C \geq D$ $L \leq M < N = O \leq P$ Premiss 1 : $C \neq O$ Premiss 2 : $A \neq L$ a. if both premises are correct b. if both premises are incorrect c. if premiss 1 is correct and premiss 2 is incorrect or uncertain d. if premiss 1 is incorrect or uncertain and premiss 2 is correct e. if both premises are uncertain

35	Please enter the number 6, 7, 8, 9, 10, 11, 12, 13, and 14 into the table each cell by the summarization must be 30 in row, column and diagonal.  

Thank you so much for your help.

Tests

(Thai language)

แบบทดสอบ

เอกสารนี้ เป็นแบบวัดทักษะทางการคิด เพื่อใช้เป็นเครื่องมือในการวิจัยของท่านโปรดคิด พิจารณาอย่างรอบคอบก่อนตอบคำถาม คำตอบของท่านจะเป็นประโยชน์อย่างยิ่งต่อการวิจัย และคำตอบของท่านจะถูกเก็บเป็นความลับ และจะไม่ส่งผลใด ๆ ต่อตัวท่านทั้งสิ้น (ถ้าข้อไหนทำไม่ได้ให้ข้ามไปทำข้อต่อไป)

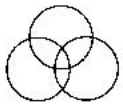
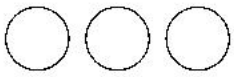
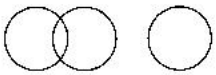
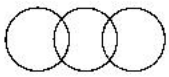
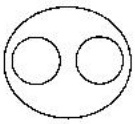
- ท่าน เพศ .....
- เกรดเฉลี่ย (GPA) ล่าสุดของท่าน คือ .....

ข้อ	**คำชี้แจง** โปรดวงกลมรอบตัวเลือกที่มีความสัมพันธ์เหมือนหรือลักษณะเดียวกับคำที่กำหนดให้มาแล้ว
1	เป็ด : ไข่ ⇒ ผีเสื้อ : ? ดักแด้ a. หนอนผีเสื้อ b. หนอน c. บุ้ง d. แมลง e.
2	ฉลาม : ปลา ⇒ นกอินทรี : ? งู a. นกเล็ก ๆ b. ปลา c. หนู d. ชากสัตว์ e.
3	กระดาษ : ต้นสอ ⇒ คอมพิวเตอร์ : ? แป้นพิมพ์ a. จอภาพ b. หน่วยความจำ c. ลำโพง d. เครื่องพิมพ์ e.
4	แปรงสีฟัน : ยาสีฟัน ⇒ ? : ? ต้อน : ตะปู a. ซ่อน : ล่อม b. ผู้ชาย : ผู้หญิง c. พู่กัน : สี d. เครื่องซักผ้า : ผงซักฟอก e.
5	ภาพวาด : จิตรกร ⇒ ? : ? เพลง : นักร้อง a. ข้าวสาร : พ่อครัว b. นักเรียน : ครู c. ลูก : พ่อ d. หนังสือ : นักเขียน e.
	คำชี้แจง ข้อ 6- 7 โปรดเลือกตัวเลือกที่มี<u>คุณลักษณะต่างหรือไม่เข้าพวก</u> จากตัวเลือกอื่น ๆ
6	A a. B b. E c. I d. O e.
7	BW a. FJ b. KR c. PY d. VT e.
	คำชี้แจง ข้อ 8 - 10 โปรดเลือกตัวเลือกที่มี<u>คุณลักษณะเหมือนหรือเป็นพวกเดียว</u>กับตัวเลือกอื่น ๆ
8	500 บาท 100 บาท 50 บาท ... 20 บาท a. 10 บาท b. 5 บาท c. 2 บาท d. 1 บาท e.
9	เสือโคร่ง เสือดาว สิงโต ... ช้าง a. ม้า b. ยีราฟ c. หมาป่า d. กวาง e.

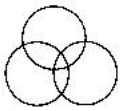
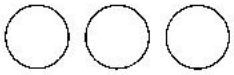
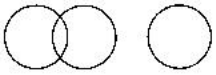
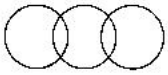
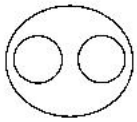
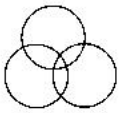
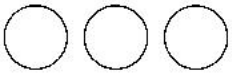
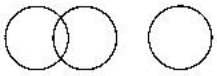
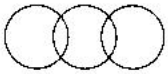
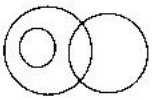
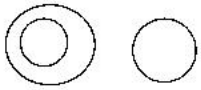
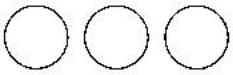
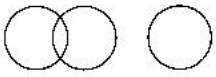
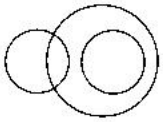
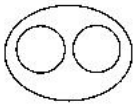
10	เครื่องบิน รถบัส รถไฟ ... รถไถ รถยก เรือข้ามฟาก เกวียน จักรยาน a. b. c. d. e.
11	ให้อธิบายว่า คุณจะพา สุนัข ไก่ และเป็ด ข้ามสะพานอย่างปลอดภัยได้อย่างไร โดยที่คุณสามารถพาสัตว์ไปกับคุณได้ครั้งละหนึ่งตัวเท่านั้น โดยคุณ**ไม่สามารถปล่อยให้สุนัขอยู่ตามลำพังกับไก่ หรือ เป็ดได้**

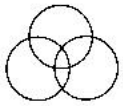
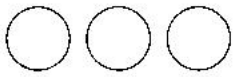
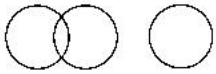
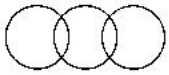
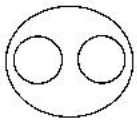
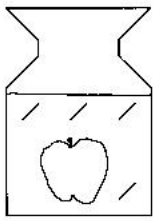
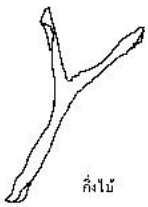
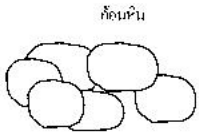
	คำชี้แจง ข้อ 12 - 16 โปรดหาข้อสรุปจากเงื่อนไขที่กำหนดให้
12	นักเรียนที่ตั้งใจเรียนจะสอบได้คะแนนสูง กุ้งและไก่สอบได้คะแนนสูง แต่มดและกระรอกสอบได้คะแนนต่ำ ช้างกำลังตั้งใจเรียนเพื่อจะสอบเข้ามหาวิทยาลัยปีหน้า ตัวเลือกใดสรุปได้ถูกต้อง a. ไก่ตั้งใจเรียน b. มดไม่ตั้งใจเรียน c. มดตั้งใจเรียนน้อยกว่ากุ้ง d. กุ้งและไก่ตั้งใจเรียนพอสมควร e. ช้างจะได้คะแนนสอบสูง
13	นักเรียนบางคนสามารถผ่านการสอบได้ถ้าพวกเขายังเรียน สมชายยังเรียน แต่สมหญิงยังเรียนมากกว่า พี่ชายของสมชายเรียนจบปริญญาตรีเมื่อปีที่แล้ว ดังนั้น ... a. สมชายสามารถผ่านการสอบได้ b. สมหญิงไม่สามารถผ่านการสอบ c. พี่ชายของสมชายไม่สามารถผ่านการสอบ d. สมชายและสมหญิงสามารถผ่านการสอบ e. ยังสรุปแน่นอนไม่ได้
14	นกทุกตัวบินได้ อินทรีเป็นนก ค้างคาวไม่ใช่นก ดังนั้น... a. ค้างคาวไม่สามารถบินได้ b. อินทรีบินได้ c. อินทรีและค้างคาวบินได้ d. อินทรีและค้างคาวบินไม่ได้ e. ค้างคาวบินได้
15	สัตว์เลี้ยงอาศัยอยู่กับมนุษย์ได้ แมวบางชนิดเป็นสัตว์เลี้ยง มีมีเป็นแมว ทอมไม่ใช่แมวแต่ทอมเป็นสัตว์เลี้ยง ดังนั้น ... a. มีมีอาศัยอยู่กับมนุษย์ได้ b. มีมีอาศัยอยู่กับมนุษย์ไม่ได้ c. ทอมอาศัยอยู่กับมนุษย์ได้ d. ทอมอาศัยอยู่กับมนุษย์ไม่ได้ e. ทั้งมีมีและทอมอาศัยอยู่กับมนุษย์ได้
16	ถ้างูกัดสุนัขสุนัขจะตาย ถ้าสุนัขกัดงูงูจะตาย ทอมมีคือสุนัข ลูซี่คือแมว ในเช้าวันหนึ่ง ลูซี่และงูนอนตายอยู่บนสนามหญ้า ดังนั้น ... a. ลูซี่ถูกงูกัดตาย b. งูถูกลูซี่กัดตาย c. งูถูกทอมมีกัดตาย d. ลูซี่และงูกัดซึ่งกันและกันจนตาย e. ยังสรุปไม่ได้

20	A, C, F, J, ... a. B b. K c. L d. M e. O
21	1, 2, 6, 15, 31, ... a. 45 b. 56 c. 64 d. 100 e. 128
22	49, 14, 36, 12, 25, 10, ... a. 18 b. 16 c. 14 d. 10 e. 8
23	มีกระเป๋าหนังสือใบหนึ่งหนักมากกว่าที่ท่านจะยกขึ้นบ้านชั้นบนได้ ท่านจะทำอย่างไร ถ้าท่านอยู่คนเดียว และท่านจำเป็นจะต้องยกกระเป๋าหนังสือนี้ขึ้นชั้นบนเดี๋ยวนี้ โปรดอธิบาย

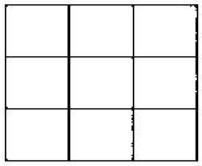
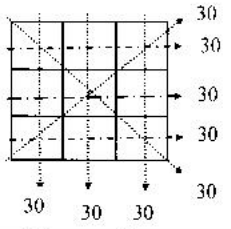
	คำชี้แจง ข้อ 24 - 28 โปรดเลือกแผนภาพที่แสดงความสัมพันธ์ของคำที่กำหนดให้มา
24	คอมพิวเตอร์, แป้นพิมพ์, เม้าส์ a.  b.  c.  d  e. 

5

25	ที่นอน, หมอน, ผ้าห่ม a.  b.  c.  d.  e. 
26	ดอกไม้, ประดู่, แจกัน a.  b.  c.  d.  e. 
27	ส้มโอ, ฝรั่ง, มังคุด a.  b.  c.  d.  e. 

28	โต๊ะ, เก้าอี้, บ้านนัง a.  b.  c.  d.  e. 
29	ในขวดโหลมีน้ำและแอปเปิลจมอยู่ก้นโหล ท่านจะหยิบแอปเปิลจากขวดโหลอย่างไร โดยไม่ให้มือเปียกน้ำ โดยในบริเวณนั้นมีแต่กิ่งไม้ และ ก้อนหิน   

	คำชี้แจง ข้อ 30 – 34 โปรดเลือกตัวเลือกที่ถูกต้อง นายสมศักดิ์ ลูกคนแรกของนางสมหญิงกับนายสมชาย มีลูกสามคนคือ นายสมคิด นายสมนึก และนายสมปอง ตามลำดับ ลูกคนสุดท้องของนางสมหญิง คือนางสมใจ แต่งงานกับนายสมควร มีลูกด้วยกันหนึ่งคนคือ นางสาวสมถวิล ส่วนพี่สาวของนางสมใจคือ นางสมปรารถนา มีลูกหนึ่งคน คือ นายสมหวัง ป้าของนายสมหวังรักนายสมหวังมาก แต่น้องชายของนายสมศักดิ์ไม่ชอบนายสมหวัง เพราะนายสมหวังเกเร ไม่ตั้งใจเรียน (ใช้ตอบข้อ *30 - 31*)

30	ใครเป็นน้าของนายสมหวัง a. นายสมศักดิ์ d. นายสมชาย b. นางสมใจ e. นางสาวสมถวิล c. นายสมปอง
31	ข้อใดเรียงจากอายุมากไปยังอายุน้อย a. นายสมชาย นางสมปราถนา นางสาวสมถวิล d. นายสมศักดิ์ นายสมชาย นายสมปอง b. นางสมปราถนา นายสมศักดิ์ นายสมหวัง e. นายสมนึก นายสมปอง นายสมหวัง c. นายสมปอง นายสมหวัง นางสาวสมถวิล
32	ลิฟท์ตัวหนึ่งบรรจุคนได้สูงสุด 6 คน เคลื่อนที่จากชั้นหนึ่งถึงชั้นหก ในชั้นที่สองมีคน1 คนเข้าลิฟท์ แต่ในชั้นที่สาม มีคน 2 คนออกจากลิฟท์ มี 1 คนเข้าลิฟท์ในชั้นที่สี่ และ2 คนออกจากลิฟท์ในชั้นที่ห้า ในชั้นที่หกไม่มีคนออกจากลิฟท์แต่มีคนเข้ามาอีกห้าแล้วลิฟท์เต็มพอดี อยากทราบว่า มีคนกี่คนที่เข้าลิฟท์ในชั้นที่หนึ่ง a. 0 d. 3 b. 1 e. 4 c. 2
33	$A \leq B = C \neq D$ ข้อสรุปใดถูกต้องในทุกกรณี a. $A = D$ d. $A - C$ b. $A \neq D$ e. $B \neq D$ c. $A < C$
34	โปรดเลือกตัวเลือกที่เป็นไปตามเงื่อนไขที่กำหนดให้ต่อไปนี้ เงื่อนไข : $A > N \leq B < C \geq D$ $L \leq M < N = O \leq P$ ข้อสรุปที่ 1 : $C \neq O$ ข้อสรุปที่ 2 : $A \neq L$ a. ข้อสรุปทั้งสองถูกต้อง b. ข้อสรุปทั้งสองไม่ถูกต้อง c. ข้อสรุปที่ 1 ถูกต้อง และข้อสรุปที่ 2 ไม่ถูกต้องหรือไม่แน่นอน d. ข้อสรุปที่ 1 ไม่ถูกต้องหรือไม่แน่นอน และข้อสรุปที่ 2 ถูกต้อง e. ข้อสรุปทั้งสองไม่แน่นอน
35	จงใส่หมายเลข 6 7 8 9 10 11 12 13 และ 14 ลงในตาราง ช่องละหนึ่งตัวเลขไม่ซ้ำกัน โดยให้ผลรวมทาง<u>แนวตั้ง แนวนอน และทแยงมุม</u> เท่ากับ 30  

Appendix B

P and r value

	Item	Ph	Pl	Ph - Pl	Ph + Pl	P	r
analogy	1	6	3	3	9	.41	.27
	4	11	6	5	17	.77	.45
	5	10	7	3	17	.77	.27
	7	5	2	3	7	.32	.27
	8	8	5	3	13	.59	.27
classifica-tion	12	10	7	3	17	.77	.27
	13	6	2	4	8	.36	.36
	15	4	1	3	5	.23	.27
	16	10	7	3	17	.77	.27
	17	11	4	7	15	.68	.64
inference	21	7	4	3	11	.50	.27
	22	8	5	3	13	.59	.27
	23	7	3	4	10	.45	.36
	25	8	4	4	12	.55	.36
	26	7	4	3	11	.50	.27
series	32	9	5	4	14	.64	.36
	33	11	6	5	17	.77	.45
	34	9	3	6	12	.55	.55
	35	11	5	6	16	.73	.55
Logical Diagram	37	7	3	4	10	.45	.36
	41	7	3	4	10	.45	.36
	42	9	6	3	15	.68	.27
	43	6	3	3	9	.41	.27
	44	5	1	4	6	.27	.36
Analytical reasoning	46	10	5	5	15	.68	.45
	47	8	4	4	12	.55	.36
	48	8	3	5	11	.50	.45
	49	6	3	3	9	.41	.27
	50	7	1	6	8	.36	.55
Problem solving	55	9	1	8	10	.45	.73
	56	8	0	8	8	.36	.73
	57	9	0	9	9	.41	.82
	58	11	0	11	11	.50	1.00
	59	7	0	7	7	.32	.64

Appendix C

Index of item objective congruency (IOC)

This is the document for finding the index of item objective congruency. I would like to know it can measure the objective of the content that I explain or not.

If you believe that question can measure the objective, please ticks (√) agree. If you believe that question cannot measure the objective, please tick (√) disagree; however, if you are not sure, please tick (√) unsure

1. Analogy

Objective, the 10 following items aims to find out the similarity in some respects between things that are otherwise dissimilar. It is a form of logical inference or an instance of it, based on the assumption that if two things are known to be alike in some respects, then they must be alike in others.

Item	Instruction: Please select a choice which has correlation the same with the given word before	agree	unsure	disagree
1	duck : egg ⇒ butterfly : ? chrysalis caterpillar worm parasite tussock moth (a.) b. c. d. e.			
2	desk lamp : electricity ⇒ car : ? lubricant water petrol grease car key a. b. (c.) d. e.			
3	tree : parasite plant ⇒ human : ?			

	parasite clothes necklace lineage friend (a.) b. c. d. e.			
4	shark : fish ⇒ eagle : ? snake bird fish rat carcass a. (b.) c. d. e.			
5	paper : pencil ⇒ computer : ? keyboard monitor CPU speaker microphone (a.) b. c. d. e.			
6	book : read ⇒ clothes : ? sew sell clean wear iron a. b. c. (d.) e.			
7	toothbrush : toothpaste ⇒ ? : ? hammer : nail spoon : fork male : female paintbrush : paint a. b. c. d. washing machine : detergent (e.)			
8	painting : painter ⇒ ? : ? song : singer meat : cook student : teacher child : father book : writer a. b. c. d. (e.)			
9	tiger : ? ⇒ ? : water forest, fish cage, bird meat, fish mountain, tree beer, human (a.) b. c. d. e.			
10	? : grass ⇒ ? : insect			

	monkey, fish cow, frog fish, bird lion, bat bear, human a. b. c. d. e.			

2. Classification

Objective is the act of distributing things into classes or categories of the same type. It is the systematic grouping of organisms according to the structural or evolutionary relationships among them. Organisms are normally classified by observed similarities in their body and cell structure or by evolutionary relationships based on the analysis of sequences of their details.

Item	Instruction: Item 1- 5 *please select a choice which its' character differ from others*	agree	unsure	disagree
11	15 23 31 49 59 a. b. c. d. e.			
12	Sunday Monday Tuesday Wednesday Thursday a. b. c. d. e.			
13	A B E I O a. b. c. d. e.			
14	BW FJ KR PY VT a. b. c. d. e.			
15	Beer Wine Whisky Tea Champagne a. b. c. d. e.			
	Instruction: Item 6 - 10 *please select a choice which its' character is same as given*			
16	(Time) 05.00 07.00 09.00 … 11.00 13.00 15.00 17.00 19.00 a. b. c. d. e.			

17	£50 £20 £10 … £5 £1 50p 20p 10p a. b. c. d. e.			
18	Tiger Hyena Lion … Elephant Horse Giraffe Cheetah Buffalo a. b. c. d. e.			
19	Plane Bus Train … Tractor Crane Ferry Horse Bicycle a. b. c. d. e.			
20	Toaster Desk lamp TV … Torch Washing machine Mobile phone Laptop Camera a. b. c. d. e.			

3. Inference

Objective is to act or process of deriving logical conclusions from premises known or assumed to be true.

Item	Instruction: Item 1- 10 *please find the conclusion from the given premises*	agree	unsure	disagree
21	If it is raining, I will bring an umbrella with me. Today is a sunny day but the weather forecaster say ‘it might rain tonight’. Which conclusion is correct? a. I bring an umbrella. d. I will get wet tonight.			

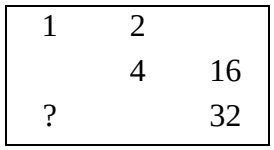
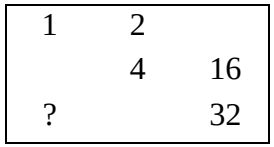
	b. I do not bring an umbrella. (e.) It is not raining now. c. I will not go out.			
22	If I read a lot of books, I can be a writer. I read a lot of books and eat a lot of food too. After that I go to bed for a long time. Which conclusion is correct? (a.) I can be a writer. d. I have got sick. b. I cannot be a writer. e. I am so hungry. c. I am a lazy person.			
23	Students who concentrate on the studying will get good score. Sean and Andrew get high score but Tom and Peter get low score. John who are studying in another school concentrate on the studying for university entry next year. Which conclusion is correct? a. Andrew concentrate on the studying. d. Sean and Andrew concentrate on b. Tom does not cancentrate on the studying. the studying the same level. c. Tom cancentrate on the studying less than Sean. (e.) John will get good score.			
24	Some students can pass the test if they study hard. Tom study hard; however, Sean study harder. Tom's brother has graduated last year. Therefore … . a. Tom can pass the test. d. Tom and Sean can pass the test. b. Sean cannot pass the test. (e.) Cannot conclude. c. Tom's brother can pass the test.			
25	All bird can fly. Turkey is a bird. Fly is not a bird. Therefore … . a. Fly cannot fly. d. Both fly and turkey cannot fly. (b.) Turkey can fly. e. Cannot conclude. c. Both fly and turkey can fly.			
26	All fruits can be eaten. Tomato is vegetable. Apple is fruit. Therefore … (a.) Apple can be eaten. d. Tomato cannot be eaten.			

	b. Apple cannot be eaten. e. Both can be eaten. c. Tomato can be eaten.			
27	Pet can live with human. Some cats are pet. Mimi is a cat but Jaguar is not a cat. Jaguar is a pet. Therefore … . a. Mimi can live with human. d. Jaguar cannot live with human. b. Mimi cannot live with human. e. Cannot conclude. (c.) Jaguar can live with human.			
28	If a snake bite a dog, the dog will die. If a dog bite a snake, the snake will die. Tommy is a dog. Luzy is a cat. In the morning, Luzy and a snake died on the yard. Therefore … . a. Luzy was bit by snake. d. Luzy and snake bit each other. b. Snake was bit by Luzy. (e.) Cannot conclude. c. Snake was bit by Tommy.			
29	Some policeman are corruption. Good policeman do not corrupt. John is a policeman who have never corrupted. Therefore… a. John is a good person. d. John has corrupted before. (b.) John is a good policeman. e. John cannot get promotion. c. John has some bad friends.			
30	A musician can play at least one music instrument. John can play flute, guitar and saxophone. Micheal play drum, and Peter sing songs. a. They are music band. (d.) John and Micheal are musician. b. Micheal is not musician. e. Peter is not musician. c. John can sing song while playing the guitar.			

4. Series

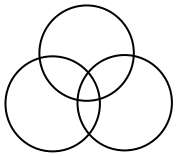
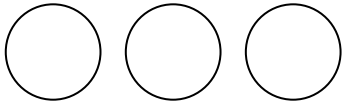
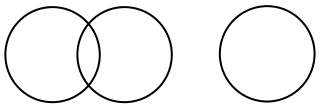
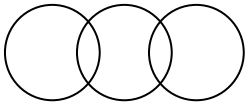
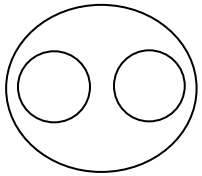
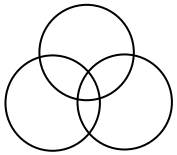
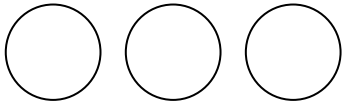
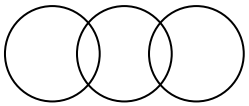
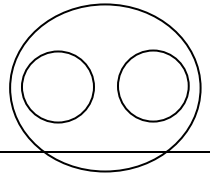
Objective: A number of objects or events arranged or coming one after the other in succession.

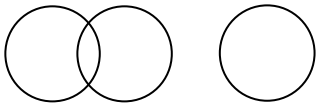
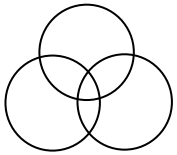
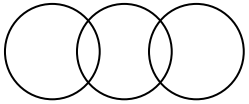
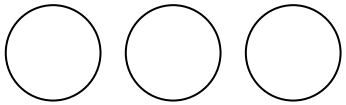
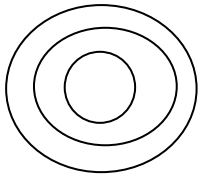
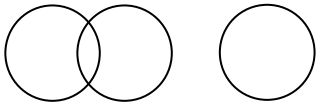
Item	Instruction: Item 1- 10 *please select a choice which can be in the series.*	agree	unsure	disagree
31	Vice chancellor, Divisional director, Director of (EdD), … a. Student d. Staff b. Lecturer e. Professor c. Secretary			
32	Unlock a car, Open the door, Get in, … a. Step on the break d. Increase the speed b. Close the door e. Stop a car c. Drive a car			
33	In coming call, Receive a call, Talk, … a. Hang on d. Gossip b. Hang up e. Go out suddenly c. Pay the bill			
34	Go to market, Buy an apple, Go home, … a. Eat it d. Clean it b. Throw it away e. Peel it c. Sell it			
35	A, C, F, J, … a. B b. K c. L d. M e. O			
36	1, 2, 6, 15, 31, … a. 45 b. 56 c. 64 d. 100 e. 128			

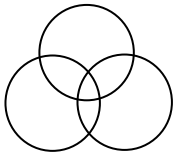
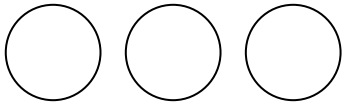
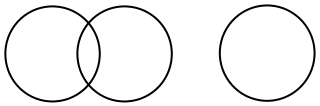
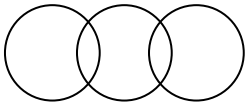
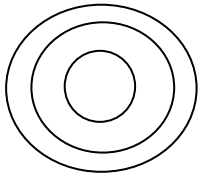
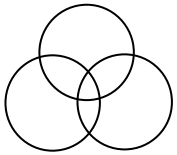
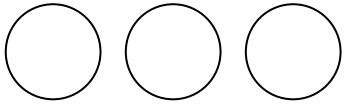
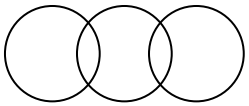
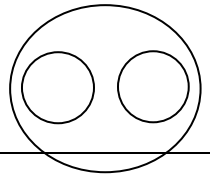
37	49, 14, 36, 12, 25, 10, … a. 18 (b.) 16 c. 14 d. 10 e. 8			
38	1, 2, 3, 5, 8, 13, … a. 19 b. 20 (c.) 21 d. 24 e. 26			
39	 1 2 4 16 ? 32 a. 3 b. 14 c. 15 (d.) 19 e. 20			
40	 1 2 4 16 ? 32 (*Nothing wrong with this table*) a. 2 b. 4 (c.) 8 d. 16 e. 20			

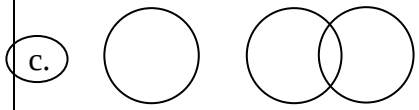
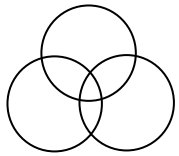
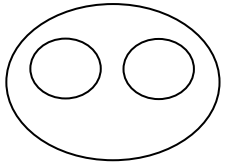
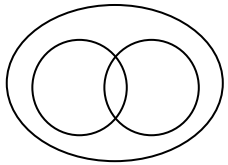
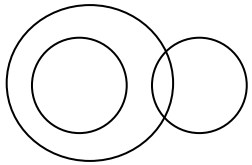
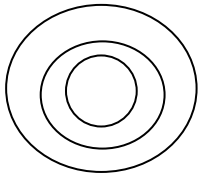
5. Logical diagrams

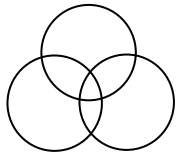
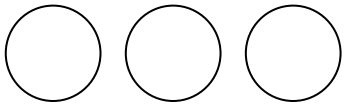
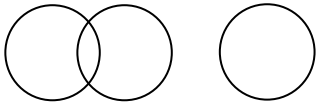
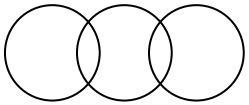
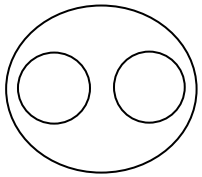
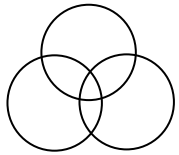
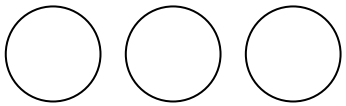
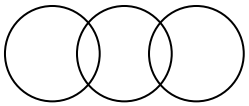
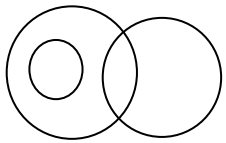
Objective: a diagram based on earlier or otherwise known statements, events, or conditions; reasonable.

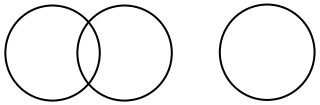
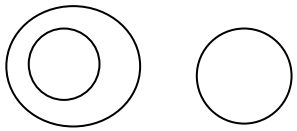
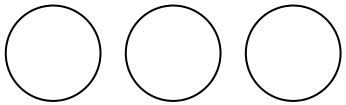
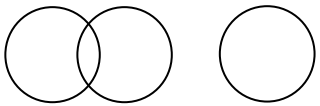
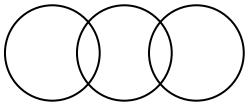
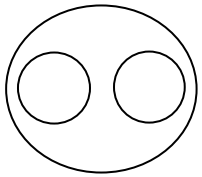
Item	Instruction: Item 1- 10 *please select a diagram which shows relationship of the assigned words.*	agree	unsure	disagree
41	TV, Radio, Pencil a.  b.  c.  d.  e. 			
42	Computer, Keyboard, Mouse(computer device) a.  b.  d.  e. 			

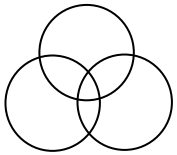
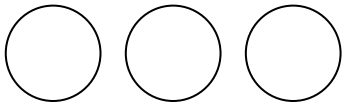
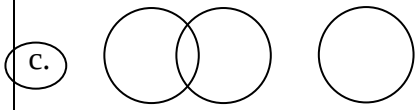
	c. 			
43	Calculator, Stone, Pen a.  d.  b.  e.  c. 			

44	Letter, Envelope, Stamp a.  b.  c.  d.  e. 			
45	Book, Pen, Pencil a.  b.  d.  e. 			

	c. 			
46	The Sun, The Earth, The Moon a.  b.  c.  d.  e. 			

47	Mattress, Pillow, Blanket a.  b.  c.  d.  e. 			
48	Flower, Door, Vast a.  b.  d.  e. 			

	c. 			
49	Lungan, Apple, Cherry a.  b.  c.  d.  e. 			

50	Table, Chair, Desk a.  b.  c. 			

6. Analytical reasoning

Objective: To analyze by examining methodically by separating into parts with reasoning

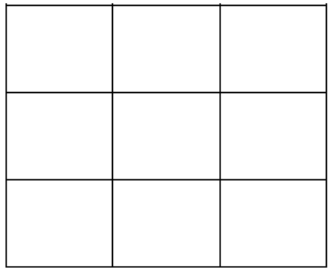
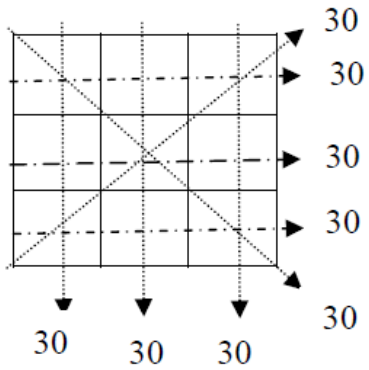
Item	Instruction: *answer question 1 – 5*	agree	unsure	disagree
51	The Sun smaller than the Earth and the Mercury. The Venus has the same size with the Jupiter but bigger than the Earth. Which one is the smallest?			

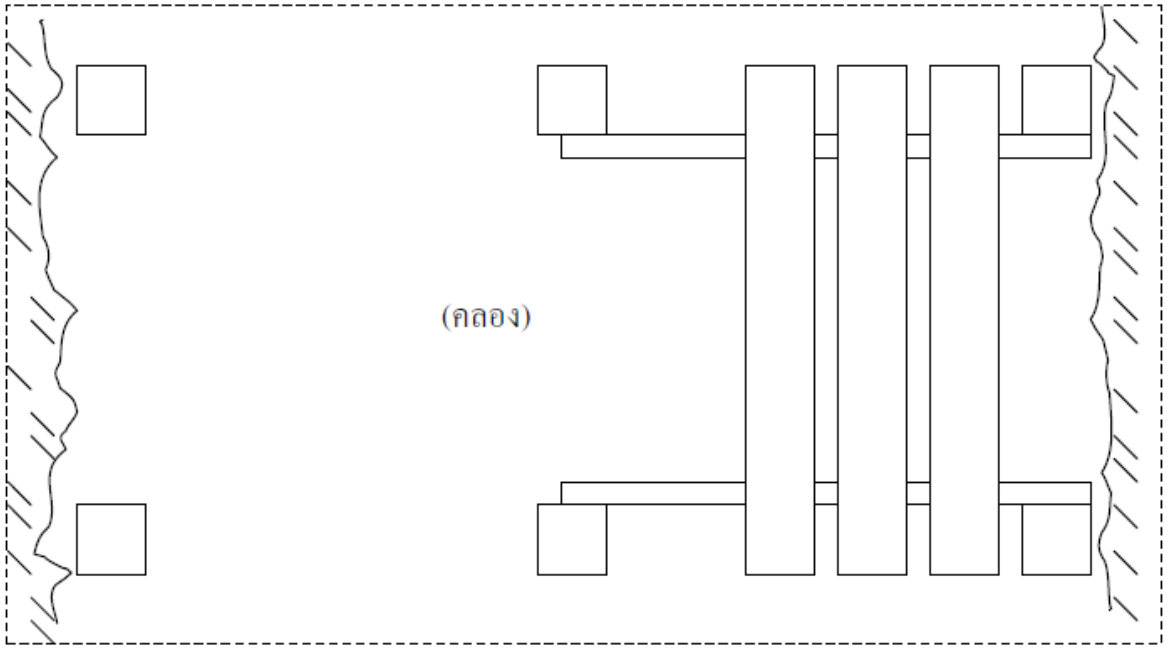
	a. The Earth b. The Jupiter c. The Mercury d. The Sun e. The Venus			
52	Sean has money more than Tom but less than Andrew and Peter. Who has the least money? a. Sean b. Tom c. Andrew d. Peter e. Andrew and Peter			
53	Sean is higher than Tom but shorter than George. Catherina and Jessi are the same hight. Who is the highest? a. Sean b. Tom c. George d. Catherina e. Jessi			
54	A six persons' lift move from the first floor to the sixth floor. On the second floor, there are two people get into the lift, three people get into on the third floor, one person get out on the forth floor, four people get out on the fifth floor and six people get into the lift on the sixth floor. How many people get into the lift on the first floor? a. No one b. 1 c. 2 d. 3 e. 4			
55	$A \leq B = C \neq D$ Which conclusion is 100% true? a. $A = D$ b. $A \neq D$ c. $A < C$ d. $B = D$ e. No one is correct.			

	Instruction: Item 6 – 10 *please select a choice depending on the following condition*. Select a. if both premises are correct b. if both premises are incorrect c. if premiss 1 is correct and premiss 2 is incorrect or uncertain d. if premiss 1 is incorrect or uncertain and premiss 2 is correct e. if both premises are uncertain Condition: $A > N \leq B < C \geq D$ $L \leq M < N = O \leq P$			
56	Premiss 1 : $C \neq O$ Premiss 2 : $A \neq L$ Answer is a.			
57	Premiss 1 : $A = C$ Premiss 2 : $D \neq L$ Answer is e.			
58	Premiss 1 : $A = P$ Premiss 2 : $C \neq M$ Answer is d.			
59	Premiss 1 : $B = M$ Premiss 2 : $A = O$ Answer is b.			
60	Premiss 1 : $L = P$ Premiss 2 : $M < C$ Answer is d.			

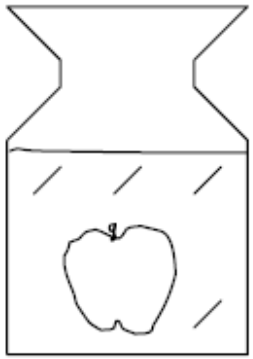
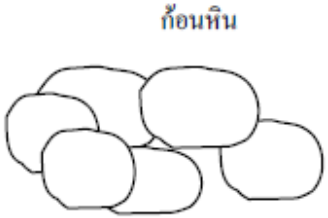
Problem solving ability

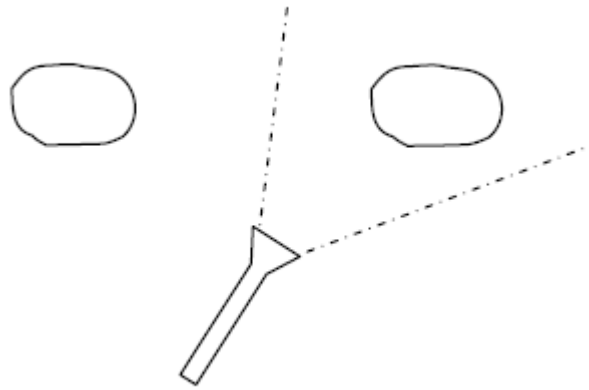
Objective: To find out ability to solve the problem.

Item	Instruction: *answer question 1 – 7*	agree	unsure	disagree
61	Please enter the number 6, 7, 8, 9, 10, 11, 12, 13, and 14 into the table each cell by the summarization must be 30 in row, column and diagonal.  			
62	Would you please rebuild the bridge (from the picture) for people crossing the river?			


(คลอง)

63	Please explain how you can across the river with only one animal at a time while you have a dog, a duck, and a chicken with you. You cannot let dog stay with any animal without you.			
64	How can you move a too heavy book bag up to the second floor in your house without any help?			

65	How can you get an apple if you do not want your hand get wet? In that area has only small branch and stone. (see picture)   กิ่งไม้  ก้อนหิน			

66	At the night time, how can you see the both stones at the same time if the stones cannot move. (see the picture) 			

67	You are going to the interview for a job which is very importance for you. Unfortunatrly, your car become malfunction on the way. What are you going to do and how?			

Appendix D

The reasoning skills were influenced by students' problem solving ability and academic ability

Estimates (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Reasoning_Skills	<---	Academic_Ability	.013	.006	2.133	.033	
Reasoning_Skills	<---	Problem_Solving_Ability	.348	.055	6.282	***	
Classification	<---	Reasoning_Skills	.238	.079	2.994	.003	
Inference	<---	Reasoning_Skills	.407	.113	3.601	***	
Series	<---	Reasoning_Skills	.683	.138	4.953	***	
Logicaldiagram	<---	Reasoning_Skills	.466	.119	3.912	***	
Analytical	<---	Reasoning_Skills	1.000				
Analogy	<---	Reasoning_Skills	.177	.086	2.046	.041	
Problem	<---	Problem_Solving_Ability	1.000				
GPA	<---	Academic_Ability	1.000				

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Reasoning_Skills	<---	Academic_Ability	.153
Reasoning_Skills	<---	Problem_Solving_Ability	.522
Classification	<---	Reasoning_Skills	.228
Inference	<---	Reasoning_Skills	.288
Series	<---	Reasoning_Skills	.476
Logicaldiagram	<---	Reasoning_Skills	.344
Analytical	<---	Reasoning_Skills	.593
Analogy	<---	Reasoning_Skills	.150
Problem	<---	Problem_Solving_Ability	1.000
GPA	<---	Academic_Ability	1.000

Intercepts: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
Classification	3.006	.049	61.284	***	
Inference	2.357	.067	35.392	***	
Series	2.961	.068	43.833	***	
Logicaldiagram	3.015	.064	47.259	***	
Analogy	2.532	.056	45.588	***	
Analytical	2.553	.079	32.163	***	
Problem	2.435	.071	34.409	***	
GPA	50.000	.541	92.361	***	

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Academic_Ability	<-->	Problem_Solving_Ability	.271	.698	.388	.698	
e3	<-->	e5	.213	.075	2.827	.005	
e4	<-->	e5	.199	.079	2.514	.012	

Correlations: (Group number 1 - Default model)

			Estimate
Academic_Ability	<-->	Problem_Solving_Ability	.021
e3	<-->	e5	.168
e4	<-->	e5	.168

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
Problem_Solving_Ability	1.663	.129	12.884	***	
Academic_Ability	97.297	7.552	12.884	***	
e9	.516	.147	3.519	***	
e7	.000				
e8	.000				
e2	.757	.061	12.405	***	
e3	1.351	.112	12.058	***	
e4	1.171	.116	10.092	***	
e5	1.192	.104	11.442	***	
e1	1.001	.079	12.684	***	
e6	1.355	.173	7.841	***	

Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
Reasoning_Skills	.300
GPA	1.000
Problem	1.000
Analytical	.352
Analogy	.022
Logicaldiagram	.118
Series	.227
Inference	.083
Classification	.052

Appendix E

The students' problem solving ability was influenced by reasoning skills and academic ability

Estimates (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Problem_Solving_Ability	<---	Reasoning_Skills	.806	.160	5.053	***	
Problem_Solving_Ability	<---	Academic_Ability	-.009	.007	-1.176	.239	
Classification	<---	Reasoning_Skills	.238	.079	2.994	.003	
Inference	<---	Reasoning_Skills	.407	.113	3.601	***	
Series	<---	Reasoning_Skills	.683	.138	4.953	***	
Logicaldiagram	<---	Reasoning_Skills	.466	.119	3.912	***	
Analytical	<---	Reasoning_Skills	1.000				
Analogy	<---	Reasoning_Skills	.177	.086	2.046	.041	
Problem	<---	Problem_Solving_Ability	1.000				
GPA	<---	Academic_Ability	1.000				

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Problem_Solving_Ability	<---	Reasoning_Skills	.537
Problem_Solving_Ability	<---	Academic_Ability	-.067
Classification	<---	Reasoning_Skills	.228
Inference	<---	Reasoning_Skills	.288
Series	<---	Reasoning_Skills	.476
Logicaldiagram	<---	Reasoning_Skills	.344
Analytical	<---	Reasoning_Skills	.593
Analogy	<---	Reasoning_Skills	.150
Problem	<---	Problem_Solving_Ability	1.000
GPA	<---	Academic_Ability	1.000

Intercepts: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
Classification	3.006	.049	61.284	***	
Inference	2.357	.067	35.392	***	
Series	2.961	.068	43.833	***	
Logicaldiagram	3.015	.064	47.259	***	
Analogy	2.532	.056	45.588	***	
Analytical	2.553	.079	32.163	***	
Problem	2.435	.071	34.409	***	
GPA	50.000	.541	92.361	***	

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Academic_Ability	<-->	Reasoning_Skills	1.387	.663	2.093	.036	
e4	<-->	e5	.199	.079	2.514	.012	
e3	<-->	e5	.213	.075	2.827	.005	

Correlations: (Group number 1 - Default model)

			Estimate
Academic_Ability	<-->	Reasoning_Skills	.164
e4	<-->	e5	.168
e3	<-->	e5	.168

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
Reasoning_Skills	.736	.185	3.990	***	
Academic_Ability	97.297	7.552	12.884	***	
e9	1.196	.132	9.079	***	
e7	.000				
e8	.000				
e2	.757	.061	12.405	***	
e3	1.351	.112	12.058	***	
e4	1.171	.116	10.092	***	
e5	1.192	.104	11.442	***	
e1	1.001	.079	12.684	***	
e6	1.355	.173	7.841	***	

Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
Problem_Solving_Ability	.281
GPA	1.000
Problem	1.000
Analytical	.352
Analogy	.022
Logicaldiagram	.118
Series	.227
Inference	.083
Classification	.052

Appendix F

The academic ability was influenced by students' problem solving ability and reasoning skills

Estimates (Group number 1 - Default model)

Scalar Estimates (Group number 1 - Default model)

Maximum Likelihood Estimates

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Academic_Ability	<---	Reasoning_Skills	2.424	1.195	2.028	.043	
Academic_Ability	<---	Problem_Solving_Ability	-.685	.587	-1.168	.243	
Classification	<---	Reasoning_Skills	.238	.079	2.994	.003	
Inference	<---	Reasoning_Skills	.407	.113	3.601	***	
Series	<---	Reasoning_Skills	.683	.138	4.953	***	
Logicaldiagram	<---	Reasoning_Skills	.466	.119	3.912	***	
Analytical	<---	Reasoning_Skills	1.000				
Analogy	<---	Reasoning_Skills	.177	.086	2.046	.041	
Problem	<---	Problem_Solving_Ability	1.000				
GPA	<---	Academic_Ability	1.000				

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
Academic_Ability	<---	Reasoning_Skills	.211
Academic_Ability	<---	Problem_Solving_Ability	-.090
Classification	<---	Reasoning_Skills	.228
Inference	<---	Reasoning_Skills	.288
Series	<---	Reasoning_Skills	.476
Logicaldiagram	<---	Reasoning_Skills	.344
Analytical	<---	Reasoning_Skills	.593
Analogy	<---	Reasoning_Skills	.150
Problem	<---	Problem_Solving_Ability	1.000
GPA	<---	Academic_Ability	1.000

Intercepts: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
Classification	3.006	.049	61.284	***	
Inference	2.357	.067	35.392	***	
Series	2.961	.068	43.833	***	
Logicaldiagram	3.015	.064	47.259	***	
Analogy	2.532	.056	45.588	***	
Analytical	2.553	.079	32.163	***	
Problem	2.435	.071	34.409	***	
GPA	50.000	.541	92.361	***	

Covariances: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
Problem_Solving_Ability	<-->	Reasoning_Skills	.582	.103	5.645	***	
e4	<-->	e5	.199	.079	2.514	.012	
e3	<-->	e5	.213	.075	2.827	.005	

Correlations: (Group number 1 - Default model)

			Estimate
Problem_Solving_Ability	<-->	Reasoning_Skills	.526
e4	<-->	e5	.168
e3	<-->	e5	.168

Variances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
Reasoning_Skills	.736	.185	3.990	***	
Problem_Solving_Ability	1.663	.129	12.884	***	
e9	94.120	7.628	12.339	***	
e7	.000				
e8	.000				
e2	.757	.061	12.405	***	
e3	1.351	.112	12.058	***	
e4	1.171	.116	10.092	***	
e5	1.192	.104	11.442	***	
e1	1.001	.079	12.684	***	
e6	1.355	.173	7.841	***	

Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
Academic_Ability	.033
GPA	1.000
Problem	1.000
Analytical	.352
Analogy	.022
Logicaldiagram	.118
Series	.227
Inference	.083
Classification	.052